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ELECTRO-METALLURGY

Practically Treated

By ALEXANDER WATT, F.R.S.S.A.

LECTURER ON ELECTRO-METALLURGY, ETC.; FORMERLY ONE OF THE EDITORS OF "THE CHEMIST."

SIXTH EDITION, WITH CONSIDERABLE ADDITIONS.

NEW YORK:
D. VAN NOSTRAND
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1879.

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PREFACE TO THE SIXTH EDITION.

In presenting an enlarged edition to his readers, the author indulges a hope that the additional matter will be found not only valuable in a practical point of view, but also interesting as a record of the improvements which have been introduced since this work first made its appearance.

During the last few years, the electro-deposition of nickel has become an important branch of the art, and it is fast supplanting silver as a protective and ornamental coating for other metals. The details of various processes for depositing this metal have been given in the body of the work, whilst a considerable amount of additional material of an important nature has been added to the Appendix.

Merton Road, Wandsworth,
December, 1876.

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ELECTRO-METALLURGY,

PRACTICALLY TREATED.

INTRODUCTION.

FROM a simple art almost accidentally discovered, electro-deposition has become a most extensive branch of manufacture in this and other countries. At first "electrotyping" was a very pretty and interesting toy, with which the rising generation of chemical philosophers used to amuse their friends and themselves, as they exhibited the wonderful effects which could be produced by a small galvanic battery, whose poles were immersed in a solution of sulphate of copper. How eagerly the eye used to watch the wondrous deposit of metallic copper upon the plumbagoed impression of some favorite seal! And, how delighted was the youthful philosopher when, on removing the metallic deposit from the sealing-wax impression, he found a faithful representative of the original, as capable, in its turn, of giving a sharp and delicate impression as the original itself!

This great discovery was made in this country by Mr. Spencer, and in Russia, by Professor Jacobi, nearly at the same time; so that the credit of the invention is equally due to each of them. But, as is frequently the case, it devolved upon others to turn the invention to great practical account, and as a matter of course, to a remunerative one also.

So great was the interest felt in this country—nay, almost all over the civilised world, when this beautiful discovery was made known, that persons of every grade in life devoted their attention to it. The student, the mechanic, the artist, the nobleman and the chemist, with equal zeal, though with different views, deposited copper from its solution by electro-chemical agency. Every one had his set of electrotyping apparatus, and his bath of sulphate of copper. Even among the fair sex would be found many a skilful manipulator, and in such hands, how could the art fail to give beautiful results! Everywhere this art was in vogue, and whilst it was being studied as an amusement by some, others were turning their attention to its commercial value, with a view to making it subservient to the useful purposes of life. So that in a very short time this country was well stocked with a new class of competitors—electrotypists, stereotypists, electro-platers, gilders, &c., &c.; and now that the electro-mania has subsided, it has settled itself down into a very comfortable, highly lucrative and legitimate business.

Nearly a quarter of a century having passed away since the introduction of the electro-metallurgical art, it is not to be wondered at that it has ceased to enjoy that popularity which at one time, as we have said, placed it in the hands of all as a fashionable amusement; for those who twenty years ago delighted in the art as an interesting novelty, are now many of them parents of another generation, which may, in its turn, seek to know the uses of the electric current in the deposition of metals upon each other. To aid this class of rising experimentalists, is now our pleasing task.

To those who desire to practise the arts of electro-gilding, plating, &c., with a view to applying the same to commercial purposes, it is hoped that the present work will prove of service, since it is the intention of the author to make it entirely of a practical nature, and as free as possible from technical expressions.

Having been for nearly twenty years practically engaged in the art of electro-plating and gilding, on a very extensive scale, during which period many thousands of ounces of the precious metals have been deposited by me from their various solutions, and having paid great attention to the subject of electro-deposition generally, I have, in common with others, met with many difficulties which careful experiment and perseverance have overcome. Therefore, in laying before my readers the results of my own practical experience, it is with the hope that they may prove useful to those who pursue the study of electro-deposition, either for instructive amusement or profit.

As I have, I believe, been more successful in some of my operations than many of my fellow-labourers, I will carefully describe those processes which I have found to answer best, from their certainty, economy and simplicity, and pass in review the processes usually employed by others, explaining the causes of failure and disappointment so frequently accompanying their adoption.

To render myself as intelligible to the working electro-plater and the amateur, as to the more scientific reader, I will fully explain the meaning of any technical terms which may necessarily occur in the way, so that he may not fall into errors which too frequently—more especially in a chemical art—retard the progress of study.

In depositing metals from their solutions, many forms of galvanic battery are employed. Among those most commonly known are Daniell's, Smee's, Wollaston's and Bunsen's. The first of these, Daniell's battery, has been almost abandoned, owing to the trouble which it involves to keep it in good working order. The second, Smee's battery, although far from economical, and somewhat uncertain in its action, is still employed by some, owing to the great *intensity* of the current which it produces (a quality of but little service to the electro-plater when the *quantity* is deficient, as we will presently explain). The third, Wollaston's battery, by far superior to the latter for electro-metallurgical purposes, as it yields a great *quantity* of electricity of considerable tension, is also frequently employed, or rather modifications of the same arrangement, which are fitted up with but little trouble and expense; whilst Bunsen's battery is only capable of being employed in depositing those metals which require a current of great intensity, as well as quantity. This battery, however, is quite unfit for the purpose of depositing either gold, silver, or copper.

It must be borne in mind, that in order to ensure a perfectly smooth, equal and *reguline* deposit on a metallic surface, the battery to be employed should yield a *considerable quantity of electricity of sufficient intensity* to work with activity and *uniformity*. A battery constructed with a large surface of positive and negative elements—as zinc and copper for instance—will yield a current of such feeble intensity in proportion to that quantity, that, when employed for the purposes of electro-deposition, the deposit takes place very slowly; whilst a battery consisting of a great number of small plates or cells, alternately arranged, would not only deposit the metal in a granular or pulverulent form, but would actually decompose the solution itself. Consequently, in order to obtain a good reguline deposit of any metal, a battery should be employed whose positive and negative elements are in such relative proportion as to yield a current of quantity electricity possessing sufficient intensity to enable that quantity to work well.

A form of battery which I have found most constant and certain in its action, I will describe further on, as also one which is much used in extensive operations where great power is required to deposit large quantities of metal, as in the processes of electrotyping and electro-plating.

Faraday employs the terms *anode, anelectrode,* or *positive electrode*, for the positive pole of the battery—*i.e.*, the wire which proceeds from the copper element in a battery; and *cathode, cathelectrode,* or *negative electrode*, for the negative pole—that which proceeds from the zinc element. Professor Daniell, however, objecting to the terms *anode* and *cathode*, proposed the adoption of *zincode* and *platinode,* to distinguish the positive and negative poles; but as the elements of a battery are not necessarily composed of zinc or platinum, and as, independently of the great weight which must always attach to any system propounded by Mr. Faraday, it would sound rather unmusical to speak of *leadodes*, *arbono des*, or *copperodes*, when describing the poles of a battery with an element of lead, carbon, or copper, I prefer adopting Faraday's nomenclature.

The electricity generated in a cell passes from the zinc to the copper element of the battery, and from thence it proceeds along the wire issuing from the copper, traverses the solution, and returns to the cell through the wire which is attached to the zinc element, and so on. The zinc is the *positive* and the copper the *negative* element, but the end of the wire attached to zinc becomes the *negative pole*, whilst that proceeding from the copper becomes the *positive pole.*

The *anode,* or positive pole, is that wire which is attached to the copper cylinder or plate of a battery; and to this wire or pole is suspended, in close contact, the sheet or plate of metal which is destined to re-supply the solution with the amount of metal which it loses by the deposition which takes place on the cathode or article to be coated.

The *cathode,* or negative pole, is the wire which issues from the zinc plate or bar of a battery, and it is this wire or pole, or any metallic surface which may be attached to it, which receives the deposit in the bath.

Professor Faraday denominates the solution, whether it be of silver, gold, copper, or any other metal from which a deposit is to be obtained, the *electrolyte.*

Quantity electricity, as I have already observed, is that kind of current which is produced when the battery is formed of large surfaces of the metallic element; it is this species of electricity which is most useful for the purposes of electro-deposition.

"Experience proves that, in general, the adherence of the oxides and of the metals gold, silver, copper, and lead on metals, is greater as the intensity of the current is less, within certain well-known limits; and as the solution is less concentrated." *

Intensity may be given to the quantity already existing in a series of cells or plates, by increasing their number; thus, by attaching the wire proceeding from the positive pole of one cell to the negative pole of another, and so on, until a compound battery is formed of alternate pairs. A battery thus constructed is well adapted to the purposes of electro-chemical decomposition, or *electrolisation*, the electric light, the giving of shocks, and other powerful effects of electricity; but, unless carefully applied, it would be highly injurious if devoted to electro-metallurgical operations.

An intensity current seldom lasts longer than a few hours, unless fresh exciting fluids be applied to the elements with which it is produced; but a quantity current may continue to be developed from a constant battery for months. I have known a constant battery continue in action for twelve months *without any addition whatever*, at the end of which period it still gave considerable evidences of electrical action.

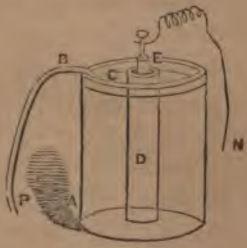


Fig. 1.

The Battery.—The battery which I would recommend to the attention of the electro-gilder, and those who desire to deposit metals by electricity on a moderate scale, consists of a cylindrical stone jar A (fig. 1), capable of holding about four gallons; inside this jar is fitted a cylinder of sheet copper C (this may be $\frac{1}{64}$th of an inch in thickness). A strip of the copper cylinder B, about half an inch broad, is cut off to within one inch, so as to form the positive electrode; my motive in doing this is to insure a perfect connection between the positive pole and the cylinder, and to save the trouble of soldering.

---

* Becquerel, "The Chemist," 1848, vol. iv. p. 400.

A circular piece of wood forms a covering to the jar; in the centre of this cover, a hole about two inches in diameter is bored, to which an ox-gullet D, or weazand, is fastened, extending to the bottom of the jar, the lower end of which is carefully tied with a piece of thick twine; or a porous cell may be used instead if preferred. A zinc bar E (fig. 2) is cast, with a long and tolerably thick copper wire in it, one end of which has been previously coiled into a helix, so as to form a spring, to prevent the breaking off of the wire at its junction with the zinc bar. The ox-gullet, or cell, is now nearly filled with a concentrated solution of common salt, to which a few drops of hydrochloric acid have been added, and the zinc bar immersed in it, but not allowed to touch the bottom of the gullet, or cell, which it may be prevented from doing by attaching a piece of wood across the zinc bar, to suspend it from the cover of the battery. The jar is nearly filled with water acidulated with two pounds of sulphuric acid and one ounce of nitric acid, and the battery is ready for use. P and N (fig.1) signify positive and negative poles.

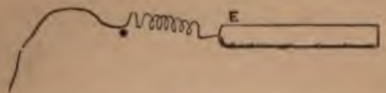


Fig. 2.

In the above form of battery several advantages present themselves; its action is constant, there is but little local action, and consequently but little waste;

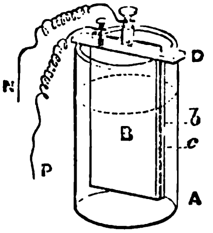
its current is regular, and it is very economical in its construction and inexpensive in use.

A compound battery thus constructed will give most powerful effects when a number of cells are used, and it will continue to give these effects for a greater length of time than any battery with which I am acquainted.

In a single cell of this battery, a considerable quantity of electricity is disengaged, of sufficient intensity for small operations, such as gilding and so forth. When it is desired to deposit a large quantity of metal in a given time, several of these cells alternated, that is, having the zinc wire of one cell united to the copper cylinder of the next, and so on, may be employed, by which arrangement a vast amount of metal may be deposited in a short time, when the solution is in good working condition. But it is preferable to unite all the copper wires and the zinc wires, by which arrangement the intensity is not increased.

In working with a Smee's battery in the large way, the rapid consumption of the zinc plates, the furious local action and offensive evolution of hydrogen gas which it is susceptible of, and the trouble and expense of amalgamating the plates, are among the many disadvantages which this battery exhibits to the practical electro-metallurgist; added to which, the current which proceeds from it is far too intense and fluctuating to enable us to obtain a smooth and reguline deposit. But for many experimental purposes this is one of the most convenient and ingenious batteries known, and Mr. Smee deserves the highest credit for its introduction, as its great popularity will testify.

Wollaston's battery, were it not for the trouble and



difficulty of replacing the zinc plates when they are consumed, and the constant application of exciting material which it requires, would be admirably suited to electro-metallurgical operations. A useful modification of Wollaston's battery, however, is now much in use. It consists of a cylindrical stone jar, A, capable of holding about ten gallons; two pieces of sheet copper are fixed upon a wooden support, D. A plate of amalgamated zinc, *c*, is placed in a groove cut in the wooden bar or support between the copper plates. A binding screw is soldered to the copper plates, B *b*, which are united by strips of copper, soldered to them, and a binding screw is to be fastened to the zinc plate. The jar is to be filled with sulphuric acid one part, water fifteen parts. The zinc must be well amalgamated.

Some electro-platers have employed magneto-electricity for the deposition of metals, but not, I think, with much success; owing, no doubt, to the fact that a current of magneto-electricity would be liable to interruption, or a want of continuity. The action of revolving armatures must necessarily be interrupted, owing to the making and breaking of contact. I maintain that, in order to obtain a fair deposit, the current of electricity applied *must be continuous.*

My brother, Mr. Charles Watt, patented a thermo-electrical battery which, if employed on a large scale, would probably eclipse all other batteries for electro-metallurgical purposes, as it possesses all the advantages of constancy, uniformity, and economy; being, in fact, *almost* costless in its action.

There are other circumstances besides the power of the battery which affect the nature of the deposit, or the speed with which it is obtained. The solution, or *electrolyte,* may be what is termed a *good* or a *bad* conductor, according to the amount of metal or the proportion of the solvent existing in it; or the extent of surface of anode or positive electrode immersed in the solution while deposition is taking place. If the solution be poor in metal, &c., and the surface of anode exposed to the article which is to receive the deposit be smaller than is required, the operation will go on slowly; whilst, on the other hand, a superabundance of metal and the solvent being in the solution, and the surface of anode exposed being considerable, the deposit may take place so rapidly that it will be thrown off the cathode, or article coated, in the form of a powder, or myriads of minute granules.

Again, the speed with which the deposit is obtained depends upon the temperature of the solution. When the solution is raised to the temperature of 60° C. (140° F.), deposition takes place very rapidly; indeed, in order to bring the solution to a strength which will enable you to use it hot without fear of granular deposition and other imperfections, nearly 75 per cent. of water must be added to it, and the surface of anode immersed be diminished.

In excessively cold weather, I have frequently found a silver solution covered with ice of considerable thickness, and consequently the deposition has taken place more slowly than was desired. In this state the deposit was much harder, and less inclined to be "rough," than when the solution was of a higher temperature. I would at all times prefer working the silver solution at as low a temperature as possible, as I think the deposit, under such circumstances, is in many respects of a superior quality.

Motion will also materially affect electro-deposition. If the solution be too strong; the surface of the anode exposed be excessive; the solution be of too high a temperature; the battery too powerful, or if any one of these circumstances give rise to a pulverulent or granular deposit, or cause the metal to "strip," or peel off the article on which it is deposited, by keeping the negative electrode and the article attached to it in constant and rapid motion until the required coating is obtained, a perfectly smooth, uniform, and tenacious deposit will be secured, though the circumstances referred to be ever so unfavourable. For example, if you attach an article to the negative electrode, and place it in the gilding bath, and if, after a few seconds, you observe that the gold is deposited of a dull brown colour, by very briskly agitating the article in the solution it will instantly become bright and of a good fine-gold colour.

There are circumstances under which no deposition whatever will take place. The following occurrence will illustrate a curious phenomenon which occurred to my brother and myself some years ago. We had been plating large quantities of spoons and forks in an apartment for several years, during which time our operations had been most highly successful, and we had been much praised for the quality of our deposit. One day my brother found, to his great annoyance, that no deposit whatever would take place on any article immersed in the solution. Something was wrong. Entirely new batteries were applied, but with no better success;

fresh solutions were made, but still no deposition of silver took place. The batteries and solutions were next insulated from contact with the ground, as we thought it probable the current was being conducted away somehow or other, and yet no favourable change occurred. Thus matters went on for nearly a fortnight; all hands were idle; the workpeople enjoyed a kind of extended Easter holiday, or were hoping something favourable would "turn up" from day to day. At last, having tried every expedient that suggested itself to our almost distracted senses, it occurred to me that if the solutions and batteries were removed to *another apartment* we might meet with better success. The experiment was tried and it succeeded. Once more we could observe the beautiful deposit of silver upon the metallic surfaces, and all went on well.

Whatever may have been the cause of this inaction, some time afterwards the operations were carried on in the same apartment with perfect facility.

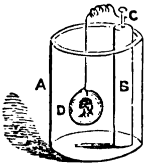
In practising the art of electro-deposition, it is necessary to observe the strictest cleanliness, and to be careful not to allow the solutions in any way to be mixed with each other.

It will be necessary to have various kinds of solutions, of certain strengths, in order to deposit one metal upon another with tenacity and firmness. The same solution will not do well for all metals. It is the neglect of this fact which causes many failures, and many solutions to be spoilt. A solution which will allow a good deposit of silver to take place on copper or brass, will not be applicable to steel, as the silver would instantly blister or peel off the latter. Again, a solution which would deposit a faultless coating of copper on iron would deposit a very bad coating on zinc.

To those who are unacquainted with science, I may observe that they need not be deterred from the study of these arts by any apparent abstruseness which may at first sight, surround it. In the present portion of this work I have been under the necessity of entering chiefly into scientific considerations: but will now commence the details of the various processes of electro-deposition, which I will endeavour to render as simple as possible, in order that they may be fully understood, even by those who now enter upon the study of this subject for the first time.

Electro-deposition of Copper.—Many valuable improvements and additions have been made by the various manipulators in the beautiful art of electrotyping; one of the first of which was Mr. Murray's application of plumbago (carburet of iron), as a coating for surfaces which were non-conductors of electricity.

Electrotypes were originally produced in a cell which formed at the same time the battery and the decomposition bath, thus:—A jar A was charged with a concentrated solution of sulphate of copper ("blue stone" or "blue vitriol"). A porous cell B, a bladder, or a glass tube having one end covered with a piece of bladder, was placed in this solution, and a piece of zinc with a copper wire C attached was placed in this cell, which was then filled with dilute sulphuric acid or salt and water; the object to be copied, being previously prepared, was suspended to the end of this wire D and immersed in the



copper solution. This was termed the "single cell" arrangement; it is even now occasionally used by electro-metallurgists in some of their operations.

Subsequently, experimentalists applied a separate battery for the purpose of depositing copper from its solution, and it was found that operations on a large scale could thus be carried on with considerable speed and other advantages. Mr. Mason has the credit of being the first who applied a separate battery to the production of electrotypes.

When a separate battery is used, it is necessary to attach the mould to be copied to the negative electrode, —the wire proceeding from the zinc of the battery, and a piece of sheet copper is attached to the positive electrode—the wire issuing from the copper of the battery. In this arrangement the object to receive the deposit constitutes the *cathode,* and the copper plate the *anode.*

Copper Solutions.—The solution for electrotyping by means of the "single cell" arrangement should be composed of a nearly saturated solution of sulphate of copper, with two ounces of concentrated sulphuric acid added to the gallon of saturated solution; one drachm of arsenious acid (white oxide of arsenic) may be also added to improve the character of the deposit, but this is not indispensable. A little chloride of tin may be substituted for the arsenic.

The sulphate of copper may be dissolved in boiling distilled or rain water, or even common water, and allowed to cool, the sulphuric acid being added when the solution is quite cold.

Sulphate of copper is frequently adulterated with sulphate of iron ("copperas" or "green vitriol"), therefore it is necessary to obtain the article at a respectable establishment; in fact it is advisable always to procure substances required for experiment, or even for more extensive operations, where their purity can be depended upon. If every one adopted this principle, those who vend impure materials would soon be compelled to follow the example of their more honest competitors, and to sell pure articles, however little in accordance with their wishes.

The solution required for depositing copper with a separate battery is composed of—

Sulphate of copper		1 pound.
Sulphuric acid		1 ,,
Water	(about)	1 gallon.

to which may be added a small quantity of arsenious acid or chloride of tin.

PREPARATION OF MOULDS.

The material of which a mould is composed will depend upon the nature of the model; the same composition will not do well for all purposes.

Moulds from Plaster of Paris Models—may be obtained by any of the following methods:—If the object to be copied be a plaster medallion, for instance, let it be placed in a plate or large saucer, with its face upwards, and pour boiling water all round it until it nearly reaches the upper edge of the cast; allow it to remain in the water until the face of the object assumes a moist, but not wet, appearance; then remove it from the plate and surround it with a rim of card or thick drawing-paper, allowing sufficient depth in the rim to hold a requisite quantity of the moulding material. This rim of card may be conveniently kept in its position by sealing-wax. A rim of sheet tin or brass will be found also to answer the purpose very well, but it must be secured to the medallion by means of fine binding wire or a split ring. The medallion must not stand for longer than two or three minutes after it is taken out of the water, before the composition is poured on. It is better to put the rim of card round the cast before immersing it in hot water. The following composition, being melted and at the point of cooling, is then poured into the mould.

White wax	6	ounces.
Spermaceti	1	,,
Stearine	8	,,
Carbonate of lead	1	,,
	16	

These compounds should be well melted together, the carbonate of lead being added last, and thoroughly stirred; care must be taken that the heat applied be not sufficient to form air-bubbles. As soon as the composition is poured on the medallion, it is advantageous to quickly stir it with a camel-hair pencil to dissipate any air-bubbles which may have resulted from pouring in the composition too suddenly. Also, the mould thus formed should remain for several hours to become quite cold; the more gradually it cools the better. The rim may now be removed and the mould separated from the medallion. Should there be a tendency for the two surfaces to adhere, the plaster cast may be again placed in boiling water for an instant, when it will come away readily. Sometimes, however, the composition will adhere to the plaster in spite of all precautions, in which case it is advisable to force it asunder, taking care not to injure the composition mould. If some of the plaster is found to adhere to the mould, place the latter in luke-warm water for a short time; this will somewhat soften the adherent plaster, and will enable portions of it to be picked off the surface of the mould, and with a very soft brush much more will come away. Should any plaster still obstinately remain adherent, dry the mould and apply with a thin piece of wood a little sulphuric acid to the fragments of plaster remaining, and leave the mould exposed to the air for some time, when the acid will have attracted a certain quantity of moisture from the air, and their united action will cause the gradual dislodgment of the plaster, which may be brushed away with a soft brush and water.

Gutta percha is another excellent substance for making moulds from plaster of Paris models. The gutta percha must be boiled in water for some length of time until it is quite soft. The object to be copied, if a plaster medallion, should have its surface slightly oiled, and then be provided with a rim as before described, and the softened gutta percha, being wiped dry and rolled into the form of a ball, placed in the centre of the model and worked with the hand until every part of the medallion is covered with it, when a smooth piece of wood (previously greased) may be placed over it and pressure applied until the mould is thoroughly set. In about an hour or so it may be removed from the model. It is necessary to bind the rim round the plaster cast *very tightly,* in order to render the object less liable to fracture and to keep the parts well together if an accident does happen; or the plaster cast may be imbedded in a little melted wax, poured on a plate, previous to the gutta percha being applied; by this means the plaster will be quite secured from fracture. Pressure may be conveniently applied by placing the mould, &c., between two pieces of perfectly flat wood and then screwing them in a vice, taking care that they be properly adjusted so that the pressure may be uniform, or a weight may be placed on the mould, and allowed to remain for half an hour or so.

Moulds in fusible metal may also be obtained from plaster casts. The plaster model should first be well soaked in boiled linseed oil, to which a little "patent dryers" has been added, and allowed to remain for several days before taking the mould, when it will have become exceedingly hard. The mould may then be taken from the plaster cast in the same way as from medals, described further on.

Elastic moulds, as they are termed, may be made from casts in plaster. The composition for this purpose is—

Glue	12 ounces.
Treacle	3 ,,

Soak the glue in sufficient water to render it quite soft. As soon as the glue is quite liquid, add the treacle and mix them well together. The plastic cast must be thoroughly saturated with boiled linseed oil, containing a little "patent dryers," and be laid aside for a day or two, if convenient, to harden before the elastic mould is made from it. This material for moulds is generally applied to objects which are either much "undercut," or are in considerable relief, and from which, consequently, it may be impossible to obtain a perfect copy without this composition is resorted to. The elastic moulds are thus made. If we desire to copy a figure of plaster, after it has been subjected to the linseed oil, &c., let the hollow in the figure be filled up with sand,

and the orifice at its base be well closed with a piece of card or oilskin pasted over it. The figure is now placed perpendicularly in a jar of cylindrical form, and rather deeper than the height of the bust; the jar should be previously well greased. The plaster cast must have an abundance of oil brushed or poured over it before it is placed in the jar, and the composition is poured in until it covers the bust and is an inch or two above it.

After allowing the mould thus formed to remain for a day or so to become thoroughly set, the jar may be turned upside down, and the mould will readily slip out. A very sharp, bright, and thin-bladed knife, is now passed from the top to the bottom of the figure at its back, very cautiously, and the mould may be opened and the plaster model withdrawn. As soon as the model is removed, the mould, being elastic, will close itself. A strip of oiled paper or rag is now carefully wrapped round the mould, in order that it may retain its proper position: it is a good plan, also, to place three or four pieces of wood of equal thicknesses, at equal distances round the mould, secured by a piece of twine; this will protect the mould from injury. The mould being inverted, is now filled with a mixture of about equal parts of bees'-wax and resin, and a small quantity of plumbago and tallow. The mixture should not be poured in until it is beginning to cool. The whole should be allowed to rest for a few hours until quite cold, when the wooden props and bandages may be removed, the mould reopened, and the composition figure gently withdrawn. The mould will do for future occasions.

When the mould is made of the wax composition, it should be treated in the following manner. Bend a piece of stout copper wire in such a way that it may, when slightly heated, be conveniently placed round a portion of the edge of the medallion, to which it will adhere firmly when cold. Then apply, with a soft camel-hair, badger-hair, or other very soft brush, finely powdered plumbago (common blacklead will do) until the whole surface of the mould has acquired a metallic lustre. The brush with which the plumbago is applied should be worked *in circles*, so that every little crevice in the mould may be thoroughly coated; it may be advisable also to plumbago the finger and rub the flat surfaces of the mould with it, in order that they may be uniformly blackleaded.

It is sometimes advantageous to breathe upon the surface of the mould when applying the plumbago; care must be taken that the end of the conducting wire attached to the mould, and that part of the composition near it, receive a good coating of the plumbago to insure a perfect connection between the wire and the plumbagoed surface. The edge of the mould should be scraped round with a knife, in order to remove any superfluous plumbago which may have been communicated by the fingers, or otherwise this part of the mould will receive the deposit, and render it difficult to separate the electrotype from the mould. But care must be taken not to remove the plumbago from the wire and adjacent composition.

The mould is now ready to be placed in the solution bath; if it is desired to obtain a good thick deposit, it may be left in the bath for two or three days or even longer. When the mould has received the required coating, remove it from the bath, detach it from the zinc element, and then gradually loosen the electrotype with the point of a penknife. Should there be any copper deposited on the outer edge of the mould, thereby rendering it difficult to separate the one from the other, this may be broken away and the obstacle thus removed. It is advisable, before taking the electrotype from the mould, to cut off the conducting wire as close to the copy as possible, in order to render the detachment more manageable.

As soon as the electrotype is free, it may be heated to cherry redness in a clear fire, or, which is better, by a blast from a blow-pipe, and when thus *annealed* it will be exceedingly tough, and less liable to be broken. When cool, the electrotype may be plunged into cold water acidulated with sulphuric acid, and allowed to remain in it for some minutes, when it may be rinsed and dried, the edges clipped with a pair of jewellers' shears, and filed to the proper form.

The electrotype may now be polished with rotten stone and oil, and applied with a rather stiff brush. It may then be washed with boiling water and soap, dried, and, lastly, polished with moistened rouge and a soft brush, the plain surfaces being polished with the second finger and rouge.

Previously to polishing the electrotype, the hollow surface at the back may be filled up with pewter solder and lead, thus:—Dissolve a piece of zinc in hydrochloric acid (muriatic acid) and apply a little of the solution all over the back of the electrotype; cut up some pewter solder into small pieces and place them on the back, put the copy on a piece of charcoal, and apply the blow-pipe flame until the solder has "run" into every crevice. Some pieces of lead may now be treated in a similar way to give additional substance to the electrotype, and it is cheaper than solder. The copy may now be bronzed, plated, or gilt, and mounted on a piece of black velvet, or otherwise disposed of, according to the taste of the electrotypist.

Moulds from Metallic Substances may be obtained by any of the following processes:—Suppose it be a medal which we desire to copy, let a stout piece of copper wire be soldered to the edge or back of the medal, or let a thinner piece of wire be twisted tightly round its edge. Then place the medal, face upwards, in a plate containing a little melted wax, suffering the wax to reach about half way up the edge of the medal, then remove it for a moment, and replace in the wax once more to give an additional coating. Or soften a piece of gutta percha, roll it into a ball, and, having cut a hole of the size of the medal in several pieces of card, or one thick piece of cardboard, place the medal, face downwards, between these holes and press the gutta percha on the back of the medal, and put a weight upon it. It may be advisable to coat the back of the medal with a solution of gutta percha, in order to give the lump applied a greater inclination to adhere, or the medal may be somewhat heated before the gutta percha is applied.

The face of the medal is now to be slightly greased either with olive oil, trotter oil, or melted goose fat. This is best done with a camel-hair pencil or a piece of cotton wool. The superfluous oil is then to be removed from the medal by means of a piece of clean cotton wool or a silk handkerchief. Solutions of wax in alcohol or turpentine have been substituted for oil or grease. The surface of the medal may also be plumbagoed with advantage, in which case the oil may be dispensed with. The medal is now to be put into the solution bath, and allowed to remain until sufficiently well coated, when it may be removed, washed, and the mould carefully separated from it.

The mould may now, in its turn, be oiled or plumbagoed, and placed in the bath, and a deposit being allowed to take place upon it, the operator will have obtained an exact representative of the original. This may now be treated in the same way as the electrotype from a wax mould.

The next process for obtaining moulds from metals, consists in first oiling or plumbagoing the surface of the medal, then placing a rim of card round its edge, secured by sealing-wax. Some very fine plaster of Paris is now mixed to the consistence of thick cream, and this is carefully poured over the face of the medal with a table-spoon; a camel-hair pencil is now used to stir the plaster on the medal, in order to dissipate any air bubbles which may have been formed when pouring on the plaster. The brush is quickly plunged into water, and the plaster allowed to remain for an hour or so to harden. When the mould is separated from the medal, it should be placed aside to dry as much as possible, and it must be well charged with melted wax before being plumbagoed. A wire may be firmly twisted round it, and the *connection* between the wire and the mould be secured by brushing the plumbago at that part only where the wire is twisted; otherwise, should the whole of the coil of wire be plumbagoed, there may be considerable difficulty in detaching the copy when the deposit is obtained. As before, all superfluous plumbago should be scraped off the edge of the mould before immersing in the bath.

Gutta percha moulds may also be obtained from metallic substances in the same way as from plaster models.

Sealing-wax has also been employed to obtain moulds from metallic surfaces, but it is not so suitable as either gutta percha or the following:—

After a medal has been oiled or plumbagoed as before, and a rim of card bound round its edge, a mould may be made of the wax and stearine composition, which is melted gradually, and when it begins to solidify, it is carefully poured on the surface of the medal, this being held at a slight angle at the time in order to prevent the formation of air bubbles. If the composition is too hot, or if the mould be too quickly removed from the medal, it will surely adhere. The mould should not be removed for several hours. If, however, with all precaution, the mould has an inclination to adhere to the medal, place them for an instant in hot water to expand the medal, when it will separate easily.

Moulds in *fusible metal,* prepared by various processes, are also obtained from medals, &c. The fusible alloy may be formed from any of the following formulæ:—

Melt together in a crucible or clean ladle

Bismuth	8 ounces.
Lead	5 ,,
Tin	4 ,,
Antimony	1 ,,
	18 ,,

While these substances are being fused, nearly fill a cylindrical jar of considerable depth, with cold water. Cut some hay or straw into pieces of about three inches in length, and place them in the water. Let some person keep this well stirred until the metal is ready to pour. The stirrer is then withdrawn quickly and the melted alloy poured in. This will finely granulate the alloy. The water being now poured off the granulated metal, it may be dried and remelted. By this means the alloy becomes thoroughly well mixed.

Or either of the following mixtures may be treated in the same way.

I.

Bismuth	8 ounces.
Lead	4 ,,
Tin	4 ,,
	16 ,,

II.

Bismuth	9 ounces.
Tin	3 ,,
Lead	6 ,,
	18 ,,

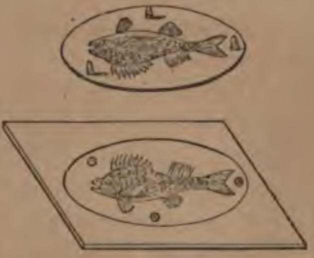
III.

Bismuth	8 ounces.
Tin	3 ,,
Lead	5 ,,
	16 ,,

When a medal is to be copied by the fusible alloy, it should be placed on a smooth piece of wood, and the edge of the medal traced round with a pencil upon the wood; a hole is now to be cut in the wood, as deep as half the thickness of the edge of the medal, and when this is done the medal is to be placed in this cavity, and made fast to it by means of moist blotting-paper or otherwise. (*See engraving.*) Or the back of the medal may be imbedded in a thick paste of plaster of Paris, up to half the thickness of its edge, and the plaster worked up so as to form a kind of handle for the medal, which should not be greased for this purpose. When the medal is secured by either of the above means, a wooden block is to be obtained, a part of which is to be greased a little, and a quantity of the fused alloy poured quickly on it, and this is to be worked up with a thin piece of wood, or card, into a mass of pasty consistence. If a pellicle appears on the surface it must be quickly removed with the card, and the medal be brought suddenly upon the cooling alloy, where it must be held steadily for a few moments until the alloy has quite *set*.

It is absolutely necessary to act with promptness and expertness, in order to obtain good moulds by means of the fusible alloy.

Moulds from Animal Substances.—Let us presume that the object to be copied is a fish. A quantity of plaster of Paris is mixed into a thickish paste, and poured quickly on a piece of plate-glass or sheet tin, slightly greased, to prevent the adhesion of the plaster; or a sheet of paper, greased on one side, placed on a level surface of wood, will answer this purpose very well. The fish may then be laid on its side upon the plaster, and a little gentle pressure applied until one-half of the fish is imbedded. (See



woodcut.) It is advantageous, sometimes, to brush oil over the fish, previous to placing it in the preparation of plaster. As soon as the adjustment of the fish is complete, it may be allowed to remain until the plaster is thoroughly *set*, but not hard; the fish may then be carefully removed from the mould thus formed, and any "ragged edges" which may appear on the mould, may be smoothed with a penknife. Three holes, of a conical form, and at least half an inch deep, should now be bored in the face of the mould, thus,—one near the middle of the fish's back, another below the head, and a third beneath the tail.

The mould must then be brushed over with soap and water, a very soft brush being applied, and the fish is then carefully replaced in its former position. Then, having made a further quantity of plaster into a *thin* paste, pour it quickly on the fish and mould, taking care that the three holes be filled with the plaster. Should any air-bubbles occur during the pouring on of the plaster, they must be instantly dissipated with a soft brush or thin piece of wood. Having applied sufficient plaster to make a strong mould, let the whole rest until the moulds are quite hard, when they may be separated and the fish withdrawn. The upper mould will have three projections, corresponding to the holes in the lower mould, which will enable the operator to put the moulds together with facility and accuracy.

These moulds may now be placed in an oven until they are quite dry, and should then be put into a shallow vessel, containing melted wax, and allowed to remain therein until they are quite saturated; as soon as the moulds are cool they are ready to receive the plumbago, or other conducting medium.

Several holes should then be drilled in the edge of each mould, and a stout copper wire, bent at one end, be inserted in each hole, the terminations of these wires being well bound together, so as to prevent the mould from shifting from the wires. Several pieces of fine wire (jewellers' binding wire will answer this purpose very well) may be twisted round the conducting wire, and their ends be allowed to touch the surface of the mould in several places, in order to aid the deposit, which, when large surfaces are exposed, is apt to take place principally or entirely at the points of the conducting wires. Care must be taken that the portions of the mould to which the wires are attached be well coated with plumbago, and the edges of the mould should be scraped, in order to free them from any plumbago which may have been communicated to them; otherwise, when the deposit is obtained, it may be found difficult to separate the mould from the electrotype.

When the two halves of the fish are thus obtained in electrotype, the extraneous copper should be removed as before directed, and being filed until they will lay close together, the inner edges may be tinned with chloride of zinc and pewter solder, and being brought together, a blowpipe flame will soon complete the union. A perfect representation of the fish is here obtained, which may be either bronzed, plated, or gilt, by any of the processes hereafter to be described.

Moulds from any animal substances may be obtained by the above plan.

In some instances it may be advisable to make a mould of an animal in the elastic material before spoken of, in which case one half of the object may be imbedded in sand, and a cylinder of sheet tin made to surround the object, and being an inch or two higher it may be stuck in the sand. The elastic material is now to be passed into the cylinder, until it nearly reaches the top; it is allowed to remain until the composition has thoroughly set, when the metal rim may be removed, and the object separated from the mould. The other half of the object may be treated in the same way. The composition of wax and stearine may now be poured into each half of the mould, and plaster moulds may be taken from the wax models thus formed, which, being saturated with melted wax, may be plumbagoed and electrotyped.

Moulds from Vegetable Substances, may be generally taken in the same way as from animals. Leaves, sea-weeds, &c., may be thus copied:—Suppose we take a fern-leaf for example: let the back of the leaf be carefully imbedded in a paste of plaster of Paris, and with a piece of wood, guide the plaster so that it may fill up every crevice that is not to be copied. When the plaster is quite hard, melted wax may be poured over the leaf (which should be dusted over with plumbago previously, to prevent the wax from adhering), and allowed to remain until quite cold. The leaf and plaster should now be separated from the wax mould, which is then ready to receive the plumbago, &c.

Another good plan is, to brush over the back of the leaf with thin plaster, layer after layer, until it has received a good stout coating; this may now be imbedded in sand, and wax poured on as before.

Fern-leaves, sea-weeds, &c., may be imbedded in clay before the wax is applied to them.

The elastic moulding will also be found very useful in copying vegetable substances.

Gutta percha can seldom be applied with advantage to the copying of delicate objects of vegetable or animal nature, owing to the amount of pressure it requires to obtain an impression.

Having described the various moulding materials employed by electrotypists, we will proceed to the general applications of the art of electrotype.

Articles of glass may be coated with copper, by first covering them with a solution of gutta percha in turpentine or naphtha, or wax dissolved in turpentine; the article is then coated with plumbago, &c., in the usual way. The surface of the glass vessel may be rendered somewhat rough by submitting it to the fumes of hydrofluoric acid, but this is seldom requisite.

In some cases it will be found difficult to apply plumbago to a given surface, in which case the following mixture may be employed:—

Wax or tallow	1 pound.
Spirit of turpentine	1 pint.
India rubber	2 ounces.
Asphalte	1 pound.

Melt the wax or tallow, then dissolve the caoutchouc and asphalte in the turpentine, and add to the wax, stirring them well. Now pour in one pound of the following solution:—

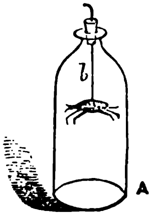
Phosphorus	1 pound.
Bisulphuret of carbon	15 pounds.

Smaller quantities may be mixed up in the same proportions.

These substances being well blended together, objects to be electrotyped are brushed over with the composition, or, being attached to a wire, are dipped into it. A weak solution of nitrate of silver is next provided, containing about two pennyweights of silver to the quart of distilled water, into which the article is immersed until it assumes a black colour all over; it is then placed in clean cold water, and afterwards dipped in a solution of chloride of gold, washed again, and allowed to dry spontaneously. The object is now ready to be placed in the bath, where it will receive the deposit very readily.

The above method of rendering non-metallic substances conductors of electricity is particularly applicable to the coating of insects, flowers, and other delicate objects of nature.

Flowers, &c., may also be dipped in a rather weak solution of nitrate of silver, and then be exposed to the fumes of phosphorus under a glass; or the object *b*, after it has been dipped in nitrate of silver, may be placed in a bottle A charged with hydrogen, or phosphuretted hydrogen.



Daguerreotypes may also be copied by the electrotype process, thus:—A portion of the back of the daguerreotype is to be cleaned by scraping it, or by applying a single drop of nitric acid, which is then to be wiped off; a little chloride of zinc is now put on the clean spot, and a small piece of thin pewter solder. A thickish copper wire, having one end flattened, is now placed in the flame of a candle or lamp, and being brought in contact with the picture, the heat is to be continued until the solder runs. The back of the daguerreotype may now be coated with wax, and may then be placed in the bath to receive the deposit of copper. The electrotype will be found easily separable from the pictures, and it should be slightly gilt, in order to protect it from oxidation.

Another useful application of the art of electrotype is the invention of Mr. Palmer, termed by him *glyphography*, a description of which process we give herewith:—

"A piece of ordinary copper plate, such as is used for engraving, is stained *black* on one side, over which is spread a very thin layer of *white* opaque composition, resembling white wax, both in its nature and appearance; this done, the plate is ready for use.

"In order to draw properly on these plates, various sorts of points are used (according to the directions here given), which remove, wherever they are passed, a portion of the white composition, whereby the blackened surface of the plate is exposed, forming a striking contrast with the surrounding white ground, so that the artist sees his effect at once.

"The drawing, being thus completed, is put into the hands of one who inspects it very carefully and minutely, to see that no part of the work has been damaged, or filled in with dirt or dust; from thence it passes into a third person's hands, by whom it is brought in contact with a substance having a chemical attraction or affinity for the remaining portions of the composition thereon, whereby they are heightened *ad libitum*. Thus, by a careful manipulation, the *lights* of the drawing become thickened all over the plate equally, and the main difficulty is at once overcome: a little more, however, remains to be done. The depth of these non-printing parts of the block must be in some degree proportionate to their width; consequently, the larger breadths of *lights* require to be thickened on the plate to a much greater extent, in order to produce this depth. This part of the process is purely mechanical, and easily accomplished.

"It is indispensably necessary that the printing surfaces of the block prepared for the press should project in such relief from the block itself, as shall prevent the probability of the inking-roller touching the interstices of the same whilst passing over them; this is accomplished in wood engraving by cutting out these intervening parts, which form the lights of the print, to a sufficient depth; but in glyphography the depth of these parts is formed by the remaining portions of the white composition on the plate, analogous to the thickness or height of which must be the depth on the block, seeing that the latter is in fact (to simplify the matter) a *cast* or *reverse* of the former. But if this composition were spread on the plate as thickly as required for this purpose, it would be impossible for the artist to put either close, fine, or free work thereon; consequently the thinnest possible coating is put on the plate previously to the drawing being made, and the required thickness obtained ultimately as described.

"The plate thus prepared is again carefully inspected through a powerful lens, and closely scrutinised, to see that it is ready for the next stage of the process, which is to place it in a trough and submit it to the action of a galvanic battery, by means of which copper is deposited into the indentations thereof, and, continuing to fill them up, it gradually spreads itself all over the surface of the composition, until a sufficiently thick plate of copper is obtained, which, on being separated, will be found to be a perfect cast of the drawing which formed the *clichée*.

"Lastly, the metallic plate thus produced is soldered to another piece of metal to strengthen it, and then mounted on a piece of wood to bring it to the height of the printer's type. This completes the process, and the glyphographic block is now ready for the press.

"It should, however, have been stated previously, that if any parts of the block require to be *lowered*, it is done with the greatest facility in the process of mounting."

For the purpose of coating iron or zinc with copper, various solutions are employed.

1. Add to a solution of sulphate of copper a solution of cyanide of potassium, which will form a greenish precipitate; care must be taken to avoid breathing the fumes arising during this part of the process, as they are highly injurious. The precipitate is to be washed several times with cold water, and lastly dissolved with cyanide of potassium.

2. Pour into a solution of sulphate of copper, a solution of ferrocyanide of potassium, until no further precipitation takes place. Wash the precipitate as before. Cyanide of potassium will dissolve the precipitate. It is recommended to work this solution hot.

3. The solution which I have found to answer best for coating iron and zinc is composed of—

Carbonate of potassa		4 ounces.
Sulphate of copper		2 ,,
Liquid ammonia	(about)	2 ,,
Cyanide of potassium		6 ,,
Water	(about)	1 gallon.

Dissolve the sulphate of copper in boiling distilled or rain water, and when cold add the carbonate of potassa and ammonia; the precipitate when formed is redissolved. Now add the cyanide of potassium, until all the blue colour disappears. A precipitate will be found at the bottom of the vessel, from which the clear solution may be separated by decantation.

The chloride or acetate of copper may be used instead of the sulphate, the former being preferable to the latter, but more expensive. Solutions thus made may be worked cold. Two cells of the battery described at page 7 will be found to answer admirably, for the purpose of depositing from these solutions.

Articles of iron which are to receive the deposit of copper should be previously soaked in a strong solution of caustic alkali, either soda or potassa, made by adding to either of these salts some recently slaked lime; the clear liquor proceeding from which is to be used for the purpose of removing any grease which may attach to the article, which is then to be well washed and immersed in a "pickle," consisting of—

Sulphuric acid	1 pound.
Hydrochloric acid	2 ounces.
Water	1¼ gallon.

After the iron article has remained in this pickle for a short time, it may be removed, and well washed and scoured with sand and water, applied with a very hard brush.

Articles of zinc may be placed in the alkali, and then steeped in the following pickle:—

Sulphuric acid	1 pound.
Water	2 gallons.

After pickling, the articles may be scoured with sand if they require it, which is seldom the case, unless the work is old and greasy, in which case the brush and sand will readily remove any stains which may present themselves after pickling.

BRONZING.

When an electrotype is obtained, or a surface of iron or zinc coated with copper, a bronze appearance may be imparted by any of the following mixtures, which should be laid on with a soft brush, and allowed to dry: after which a somewhat harder brush should be briskly applied to the object, until it has become thoroughly brightened. Should the bronze, however, appear too uniform and want relief, a little of the composition should be rubbed off the raised surfaces, in order to give an effect of light and shade. This may be done to suit the taste of the operator.

As the bronzing mixtures are of different colours, and are to produce various effects, care should be taken never to apply any two of them with the same brush, without previously washing it.

Black Bronze.—Dissolve platinum in nitro-hydrochloric acid, and evaporate to dryness, or to crystallisation. Dissolve this in spirit of wine, ether, or water. A few drops of this solution may be mixed with any of the bronzing powders, such as crocus, sienna, rouge, &c. It is well to gently heat the article to be bronzed, previous to applying this composition. The projecting portions of the article may be lightened, if requisite, by applying a little liquid ammonia to them with a piece of chamois leather.

Brown Bronze.—Rouge, with a little chloride of platinum and water, will form a chocolate brown of considerable depth of tone, and is exceedingly applicable to [illegible] shades which are required to resemble a copper bronze.

Parisian Bronze.

I.

[illegible]	1 ounce.
[illegible]	2 ,,
[illegible]	[illegible] ,,

Add a few drops of hydrosulphate of ammonia [illegible] water.

II.

Chromate of lead	2 ounces.
Prussian Blue	2 ,,
[illegible]	½ pound.
[illegible]	¼ ,,
[illegible]	¼ ,,

Add sufficient water to make a paste. To this may be added either chloride of platinum, or hydrosulphate of ammonia, according to the taste of the manipulator.

Another bronze may be made by mixing a little rouge, crocus, and hydrosulphate of ammonia in water; this should be applied several times, in order to give a body to the bronze.

Having given the principal facts connected with the electro-deposition of copper, sufficient I hope to enable the student to pursue the subject with ease and success, I now proceed to describe the various processes of Electro-Plating, in which I trust to present to the reader some useful practical information.

ELECTRO-DEPOSITION OF SILVER.

The most important of all the arts of electro-deposition is that denominated "electro-plating." This beautiful art is now practised to a vast extent in London, Sheffield, Birmingham, and Paris. Articles, chiefly made of German silver, are coated with fine silver, and thus, to a great extent, supersede the ordinary Sheffield and Birmingham plate; whilst old articles from which the silver has worn off can be replated, and thus rendered equal, and in some instances, superior to new.

Previous to the discovery of this art, when the silver had disappeared from the surfaces of plated articles by long usage, they became useless, as there was no process known by which the articles could be re-silvered.

Since the first introduction of the art, many have worked it with considerable success, and in the principal towns in England, Ireland, and Scotland, there are manufactories in which, annually, a vast amount of silver is deposited upon articles of various construction, and yet there is no superabundance of electro-platers; for I believe that if there were ten times the number, they would all do well, and for this reason: — the amount of plated goods now manufactured all over the kingdom far exceeds that made in the old days of Sheffield and Birmingham plate; and the silver which is deposited on these goods must be replaced as it wears off, in the progress of time, by the electro-plater. Again, many persons now use plated German silver goods in preference to silver, either owing to their superior beauty, their being less tempting to the marauder, or more economical to purchase. And when we bear in mind the vast quantity of electro-plate which is to be found in the hotels, restaurants, and private houses in the united kingdom—which is daily having its silver rubbed and scrubbed off, there is good reason to believe that the electro-plater's services will be extensively required, in proportion as the manufacture and consumption of electro-plate progresses.

There are many solutions employed in depositing silver upon various metals, from which we will select those most likely to succeed with the beginner and the practical man. The proportions of the materials used being the same in small or large operations, the manipulator may easily make up either of the following solutions in any quantity he pleases, from a pint to 1000 gallons or more.

Silver Solutions.—In making any of these solutions, perfectly *fine* silver must be employed; or, if it is desired to use standard or other impure silver, it will be better to purify the silver by first dissolving it in nitric acid; then add about one quart of cold water to the acid solution obtained from dissolving four ounces of silver. Now throw in a few pieces of sheet copper to precipitate the silver, and proceed as described at page 93. When the pure silver is thus obtained, it is to be again dissolved in two parts water and one part nitric acid.

Solution I.

Fine silver		1	ounce.
Nitric acid	about	1	,,
Water		½	,,

Put the silver carefully into a Florence flask, and then pour in the acid and water; place the flask on a sand bath for a few minutes, taking care not to apply too much heat, and as soon as chemical action becomes violent, remove the flask to a cooler place, and allow the action to go on until it nearly ceases; when, if there be silver still undissolved, the flask may be again placed on the sand-bath until the silver disappears. If, however, the acid employed has been weak, it may be necessary to add a little more. The red fumes formed when chemical action is going on disappear when the silver is dissolved or when the acid has done its work. If a little black powder be visible at the bottom of the flask, it may be taken care of separately, as it is gold. I have frequently found gold in the silver purchased of a refiner; in some instances more than sufficient to pay the expense of the acid employed.

The nitrate of silver formed during the above operation should be carefully poured into a porcelain or Wedgwood capsule, and heated until a pellicle appears on the surface, when it may be placed aside to crystallise. The uncrystallised liquor should then be poured from the crystals into another capsule, and heat applied until it has evaporated sufficiently to crystallise. When this is done, the crystals of nitrate of silver are to be placed in a large jar or other suitable vessel, and about three pints of cold distilled water added, the whole being well stirred with a glass rod until the crystals are dissolved.

A quantity of carbonate of potassa is now to be dissolved in distilled water, and some of the solution added to the nitrate of silver, until no further precipitation takes place. It is advisable occasionally to put a little of the clear solution in a glass, or test-tube, and to add a few drops of the solution of potassa, in order to ascertain whether all the silver is thrown down, or otherwise; as soon as the application of the alkaline solution produces no effect upon the solution of nitrate of silver, this operation is complete.

The supernatant liquor (that is, the fluid which remains above the precipitate) should next be carefully poured off the precipitated silver, and fresh water added; this is again allowed to settle, and the water poured off as before, which operation should be repeated several times in order to wash the precipitate thoroughly.

A quantity of cyanide of potassium is then to be dissolved in hot or cold water, and rather more than is sufficient to dissolve the precipitate added. In a few minutes the carbonate of silver will be dissolved by the cyanide, but in all probability there will be a trifling sediment at the bottom of the vessel, which may be separated from the solution by filtration, and preserved, as in all probability it will contain a little silver.

Sufficient water is now to be added to make one gallon of solution. Should the solution be found to work rather slowly at first, a little of the solution of cyanide may be added from time to time, as it is required: but it is preferable, in working a new solution, to have as small a proportion of cyanide as possible, otherwise the articles may *strip*, but more especially if they are composed of German silver.

When a silver solution has been worked for some length of time, it acquires organic matter, and is then capable of bearing, without injury, a larger proportion of cyanide.

It is necessary that the nitric acid employed for dissolving silver should be of good commercial quality, if not chemically pure, for if it contains hydrochloric acid (which is not an unfrequent adulteration), a portion of the silver dissolved will become precipitated in the form of a white flocculent powder (chloride of silver), and the success of the operation is thereby impaired.

Solution II.—To one ounce of silver, dissolved and crystallised as above directed, is to be added three pints of distilled water. The silver is to be precipitated from this by adding gradually a strong solution of cyanide o potassium. This must be done with caution, as an excess of cyanide will re-dissolve the precipitate. Should the operator, however, accidentally apply too much cyanide, a little nitrate of silver in solution may be added, the silver of which will be precipitated by the surplus cyanide. A portion of the solution should be placed in a wine-glass occasionally, and a drop of cyanide added, until no further effect is produced by this substance.

As soon as the precipitate (which is white) has subsided, the clear solution is to be poured off, and fresh water added, this being done several times, as before, to wash the precipitate.

Three pounds of ferrocyanide of potassium (yellow prussiate of potassa) may now be dissolved in water, and added to the precipitate. When the precipitate is dissolved, add sufficient water to make one gallon of solution, which should then be filtered before using. This solution is not very profitable to the electro-plater, as it requires fresh silver to be added frequently, owing to the fact that the anode, or silver plate, is not acted upon by the ferrocyanide, therefore the solution soon becomes deprived of its silver. It may be used, however, for experimental purposes.

Solution III.—One ounce of fine silver dissolved and treated as before, to which add three pints of distilled water. Precipitate the silver by adding a strong solution of common salt—an excess does no harm. A single drop of hydrochloric acid will show whether all the silver is thrown down or not. The white precipitate thus formed (which is chloride of silver) is to be washed as before.

A quantity of hyposulphite of soda is next dissolved in hot distilled water, and a sufficient quantity added to dissolve the precipitate. Water is then to be added to make one gallon. This solution is decomposed by light, and should therefore be kept covered up, or in a dark place. It is not much used by electro-platers.

Solution IV.—One ounce of fine silver treated as before, and dissolved in three pints of distilled water. Precipitate with common salt, and wash, as above directed. Dissolve the precipitate with a strong solution of cyanide of potassium, taking care not to add much more than will dissolve the chloride of silver. Filter carefully, at least once through the same filtering paper and once through clean filtering paper, and then add enough distilled water to make one gallon of solution.

The above solution is very useful when it is desired to plate an article delicately white, but the silver is liable to strip when the burnisher is applied to it. This solution, however, may be employed with less fear of the work stripping, if it be used weaker, with a small surface of anode and feeble battery power.

Under all circumstances this solution is more applicable to surfaces which only require to be scratch-brushed, or which are to be left *dead*. Chased figures, clock-dials, cast metal work, &c., may be admirably plated with this solution.

Solution V.—One ounce of fine silver, as before, and the crystals dissolved in three pints of distilled water. Add strong solution of cyanide of potassium until no further precipitation takes place. If too much cyanide is added, it will re-dissolve the precipitate. Pour off the supernatant liquor and wash the silver as before. Now add strong solution of cyanide to dissolve the precipitate. Make one gallon with distilled water.

The solution should have a moderate excess of cyanide, and it must be filtered before using.

Solution VI.—A silver solution may be made by dissolving one ounce of silver as before. Dissolve the crystals in one pint of distilled water. Next be prepared with a large vessel full of lime-water, made by adding recently slaked lime to an ample quantity of water, which, it must be remembered, dissolves but a very small per-centage of lime. To the clear lime-water is to be added the solution of nitrate of silver, which will be converted into a dark brown precipitate (oxide of silver). When all the silver is thrown down, the clear liquor is to be poured off, and the precipitate washed as before. Now add strong cyanide of potassium solution to dissolve the oxide of silver, and make one gallon with distilled water.

This makes a very excellent solution, although it is somewhat troublesome to prepare.

Solution VII.—Dissolve in one gallon of water one ounce and a-quarter of cyanide of potassium, in a stone-ware or glass vessel. Fill a porous cell with some of this solution, and place it in the larger vessel; the solution should be the same height in both vessels. Then put a piece of sheet copper or iron, connected with the wire which proceeds from the zinc of the battery, into the porous cell. Place in the stone vessel a piece of stout sheet silver, which must be previously attached to the wire issuing from the copper of the battery. It is well to employ several cells alternated, for this purpose, when a large quantity of solution has to be prepared; that is to say, the zinc of one battery should be united by a wire with the copper of the next, and so on. In a few hours the solution in the larger vessel will have acquired sufficient silver, and the solution may be at once used. The porous cell is to be removed, and its contents may be thrown away.

In working this solution at first it is necessary to expose a rather large surface of anode, and small quantities of cyanide must be added occasionally until the solution is in brisk working order.

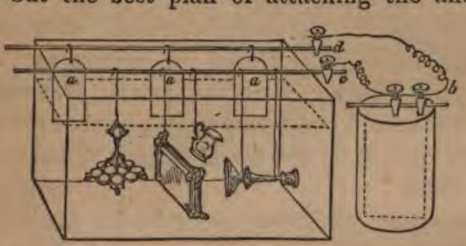
This is one of the best solutions, when carefully prepared, and is less liable to strip than many others.

Solutions of silver may be prepared by precipitating the silver from the solution of nitrate with ammonia, soda, magnesia, &c., &c., but for all practical purposes the solutions I., IV., V., VI., and VII., may, if carefully prepared, be depended upon.

When it is desired that the articles should come out of the bath having a *bright* appearance, a little bisulphuret of carbon is added to the solution. This is best done in the following manner:—Put an ounce of bisulphuret of carbon into a pint bottle containing a strong silver solution with cyanide in excess. The bottle should be repeatedly shaken, and the mixture is ready for use in a few days. A few drops of this solution may be poured into the plating bath occasionally, until the work appears sufficiently bright. The bisulphuret solution, however, must be added with care, for an excess is apt to spoil the solution. In plating surfaces which cannot easily be scratch-brushed, this brightening process is very serviceable. The operator, however, must never add too much at a time.

In making up any of the foregoing solutions the weights and measures employed are troy, or apothecaries' weight, and imperial measure, a table of which will be given at the end of this volume.

Having at command any of the solutions described, the operator may next arrange the battery. A plate *a*, *a*, *a*, or sheet of silver, is to be attached to the wire issuing from the copper of the battery *b*, and supported by a brass rod *d*; this may be done either by soldering them together or uniting them with a suitable binding screw; but the best plan of attaching the anode, or sheet of silver, to the copper wire is as follows:—Cut a strip to within half an inch or so; this strip may be united to the wire by a binding screw or soldered. If cast plates of silver are used, it is advantageous to have them cast with an extra piece, about three inches long at the corners, to attach the copper wire to.



The object in adopting either of the above arrangements is to prevent the copper wire entering the bath, as this is much impaired by allowing the copper to be immersed in the cyanide solution, whether deposition is taking place or not. Copper, if left in the bath for any length of time, even unconnected with a battery, will reduce a portion of the silver from the solution, an equivalent of the copper taking its place. This is especially the case when a large quantity of free cyanide is present.

A brass rod *e*, with a binding screw soldered or screwed on one end of it, is now to be attached to the negative wire of the battery. The articles to be coated may be suspended to this rod by pieces of clean copper wire; the wire used for this purpose may be rather thin, yet sufficiently strong to bear the weight of the articles. The thinner the wire is the less mark will be made upon the articles coated—a very important consideration in some cases, especially where spoons and forks are to be plated. This wire is termed "slinging wire." The size I generally prefer for spoons and forks is about $\frac{1}{32}$nd of an inch in thickness. The rods from which the anodes and goods to be plated are suspended must be kept quite clean and bright, by rubbing with emery cloth.

Preparation of New Work to be Plated.—German silver spoons and forks may be first placed in a hot solution of caustic soda or potassa (made by mixing recently-slaked lime with a concentrated hot solution of either soda or potassa, and allowing the lime to subside, the liquor is ready for use when further diluted), in order to remove any grease which may be upon them. A few minutes will effect this, as the caustic alkali very readily converts the small amount of grease generally on these articles into a soapy substance, easily removable by water. This process, however, is not indispensable; I seldom adopt it.

The spoons, &c., may now be well brushed with either powdered pumice-stone or powdered bath-brick (I prefer the latter) and water—a hard brush being applied to the purpose. This cleansing process is carried on until all the polish of the spoons is removed; and the fingers which hold the articles should be kept well charged with the powdered material, to prevent any grease or perspiration being imparted to the work. In cleaning spoons, it is advisable to begin at the inside of the bowl, and then to proceed to the other parts; lastly, going over the whole surface lightly, to render it uniform after the necessary handling it has been subjected to. A little practice will soon render the operator expert in these important details. The spoons, &c., are to be placed in clean cold water as soon as they are brushed, and are then ready for the bath. The slinging wires may now be attached.

When a solution is newly made, the work is apt to be irregularly coated at first, therefore it may be necessary to take the articles out of the bath about ten minutes after their first immersion, and to give them another slight rub with the brush and powdered material as before, when they should be again rinsed and placed in the solution.

If it is desired to give the spoons a very strong coating of silver, it is well, after a few hours' immersion, to remove them from the bath, and to submit them to the action of a lathe scratch-brush (consisting of a "chuck," with several bundles of fine brass wire attached to it, upon which beer or weak ale is allowed to run from a small barrel, with a tap to it, from above). This process will burnish down the white "burr," as it is called, and which consists of minute crystals of fine silver, and will prevent the coating from becoming *rough*. After the articles are scratched they should be rinsed in clean water, and again placed in the bath until done. The spoons may be lightly brushed over with moistened silver sand instead of being scratch-brushed, but the latter is preferable. When the goods have received the required coating they are again scratched, and can then be finished, either by the burnisher or polisher.

If the operator desires to know exactly how much silver is deposited on a given quantity of work, this may be done by weighing the article before and after immersion; or, by weighing the anode each time, he may form a tolerably correct estimate of the amount of silver deposited, for the anode generally supplies the solution with the amount of silver taken from it by the articles coated, that is to say, if all circumstances have been favourable.

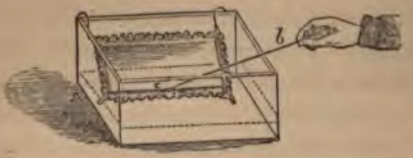
When the articles are first placed in the bath, a sufficient surface of anode should be exposed (that is, immersed in the solution) to enable the goods to become whitish in the course of a few seconds. If they assume this appearance the very instant they enter the bath, the process is going on too quickly, and the articles will be liable to "strip." I regulate the speed of the operation of electro-deposition almost entirely by the anode, and I prefer exposing a small portion of this electrode at first, until the goods are uniformly covered, when the anode is lowered, little by little, until sufficient is exposed to carry on the operation with requisite speed. But the state of the solution and the battery must also be carefully attended to.

Large goods—for example, tea-pots, cruet-frames, tea-urns, &c., may be treated in the same way as spoons and forks, but care must be taken that no impression of the fingers be left on any of the plain surfaces, as in such case a roughness will occur at that part.

Preparation of Old Work to be Plated.—Sheffield or Birmingham plated cruet, soy, and liquor frames, &c., from which the silver has worn off, should first have the bottom separated from the wire, either by unsoldering or unscrewing, as the case may be. The bottom, if it is very rough, may be rendered smooth by means of emery cloth, or pumice-stone and water, and emery cloth afterwards. It may be finished with water-of-Ayr stone. The cruet-frame wire may generally be made smooth with emery cloth only.

As soon as the parts of the frame are smooth, the edges, feet, &c., may be brushed with a hard brush and powdered Bath brick, until all the interstices are quite clean. If there be any verdigris on any part of the frame it may be removed immediately by applying a few drops of hydrochloric acid ("spirit of salt") to the part. When the edges have been well brushed, the frame should be brushed all over in the same way, and it is then ready for the solution. But if the edges or mounts are lead ("silver edges" they are generally termed), it will be necessary to apply, with a rather soft brush, a solution made by dissolving four ounces of mercury in nitric acid, and adding about half-a-pint of cold water. This solution is to be lightly brushed over the lead mounts only; the article and brush are then to be well rinsed, and the brush and plain water again applied in the same way. The solution of mercury will turn the edges black, or dark grey, but the subsequent brushing will render them bright again. The frame is now to be well rinsed and is ready for the depositing bath. If, on its first immersion, any black spots exhibit themselves, the frame may be removed, again brushed over, and finally returned to the bath. If the edges do not receive the coating of silver as readily as the other parts, the solution may require a little more cyanide, or strengthen the power of the battery, or by increasing the surface of the anode this may be accomplished.

I have successfully coated these lead edges by applying a solution of sulphate of copper A, with a little free sulphuric acid in it, thus:—I dip one portion of the edge at a time in the solution of sulphate of copper, and with a piece of iron *b*, I touch the lead edge *c*, in solution, and this in an instant becomes coated with a bright deposit of copper. This is now rinsed, and the next part of the edge is treated in the same way, and so on. By this plan lead edges may be coated with great facility and certainty of success.



Generally, underneath the bottoms of cruet frames is a coating of tin; and as this metal is very troublesome to plate, unless in a solution made expressly for it, I prefer removing the tin, either by means of nitric or hydrochloric acid (the latter being rather a slow process), or with emery cloth and pumice; but nitric acid, employed with care, is the quickest plan.

When it is wished merely to whiten an article with silver, the amount deposited being of no consideration, solution No. 4, described at page 44, should be used. Let us suppose that a time-piece dial be the object to be whitened. The dial is first cleaned with a brush in the ordinary way, until all the old silver (if any) is removed; it is then rubbed with a piece of chamois leather and finely powdered Bath brick, slightly moistened; it is better to pass the leather over the surface *in circles,* so as to render the face as uniform as possible and to prevent the deposit from being *patchy*. The dial is then to be *rinsed in* quite clean water and suspended in the bath.

If the finger has been allowed to touch the face of the dial, it will be found that that part exhibits a dulness corresponding to the form of the skin of the finger, and it will be necessary to rub the dial as before with the chamois leather. The dial should be supported by the edges only. A few minutes' immersion will be sufficient to whiten a dial. When done, it is to be plunged into boiling water, and allowed to dry spontaneously, or be placed in perfectly clean box saw-dust.

Articles which are to be left with a dead-white surface, may be prepared in the same way, but they require to remain longer in the bath; in fact, till they assume the characteristic dead-white appearance. They are then to be placed in boiling water, and finally in box-dust, the latter being removed by means of a soft brush.

When it is necessary to whiten goods very quickly, the solution may be weakened with *hot* water, and the temperature raised to about 130° Fahr. The surface of anode exposed must be less than if the solution were to be worked cold. Moving the articles about in the solution occasionally, ensures uniformity and improves the whiteness by giving it a slight transparency.

When any of the solutions have been in use for some length of time, their conductibility may be augmented by adding a little cyanide of potassium. After the first few days the solution generally works better than when newly made; therefore it is not advisable to make any alteration in it until it begins to work rather tardily, when the additional cyanide may be added. I have invariably found that a solution that has been worked for several years has given better results than one recently made, and I have never yet been compelled to resupply the solution with silver; this is simply because I have taken care to work with a sufficient *surface* of anode, with battery power of feeble intensity, and with enough free cyanide in solution to cause the anode to yield as much silver to the bath as the plated articles have from time to time removed from it.

Iron is by no means an easy metal to coat with silver. It may, however, be successfully plated with care. The iron article should first be well cleaned and rendered free from rust, either by rubbing with emery cloth, or by dipping it into a pickle composed of

Sulphuric acid	2 ounces.
Hydrochloric acid	1 ounce.
Water	1 gallon.

It may remain in this pickle until the oxide or rust becomes easily removable by a brush and wet sand. If it be found, on removing the articles from the pickle, that the oxide does not brush off easily, it should be returned to the pickle-bath. When the surface is merely rusty, strong hydrochloric acid alone will remove the rust and render the article at once clean and ready for the sand-brush. The articles when cleaned and well rinsed, may be placed in the alkaline solution of copper bath, described at page 35, and allowed to remain until they have received a slight coating; they may then be rinsed and placed in the silvering bath; or the articles may be electro-brassed by any of the processes hereafter to be described, and then immersed in the plating bath.

It is better to deposit a coating either of brass or copper upon an iron surface, to insure success. Copper will adhere well to iron, but silver will not, therefore copper acts the useful part of a "go-between," thereby preventing the disagreement that might arise were two metals, so antagonistic to each other as silver and iron, allowed to come in contact.

The solution in which iron is to be plated should be weakened with about fifty per cent. of water.

Britannia metal, pewter, and all combinations of lead and tin, are best plated in a solution containing a good deal of free cyanide. Deposition should be suffered to take place quickly at first, so as to insure the deposit going well all over the article. A larger surface of anode, also, must be exposed than would be required for German silver work—probably three times the surface.

The battery power must be energetic, but not too intense. Two 4-gallon cells of the battery described at page 10 will be sufficient for objects of considerable size. Articles made of Britannia metal, &c., should not be disturbed while in solution. They may, however, be shifted now and then so as to expose a fresh surface to the anode, for the sake of causing uniformity of deposit, but it is not advisable to let the solution be agitated more than is absolutely necessary. This caution, however, is chiefly applicable to the period when the articles are first immersed in the bath.

The goods may be prepared for plating by brushing them over with silver sand and water, with a moderately hard brush, instead of the powdered Bath brick used for other metals. The articles may be cleansed from grease by placing them for a few minutes in a hot solution of caustic soda.

If the articles, when they have been placed in the plating bath for a few moments, present an unequal surface, it is advisable to remove them, and have them brushed over again as before; then, after well rinsing, they should be quickly returned to the bath and allowed to remain without further disturbance if possible.

The readiest mode of plating articles of lead, tin, or zinc, is to previously cover them with a film of brass, in the brassing bath: or with copper, in the alkaline coppering bath. Either brass or copper will adhere firmly to the surface of these metals, and the silver may be deposited on the coppered or brassed surface with perfect facility. After the articles have been removed from the copper or brass bath, they should be well scratch-brushed and rinsed before placing in the plating bath.

When an article has been plated and is found to strip or blister in many places, it will be necessary to remove all the silver from the surface and plate it again more carefully. There are two kinds of *blistering;* the first is the non-adherence of the silver to the article coated; the second, the blistering or *doubling* of the metal of which the article is composed. When the blistering is of the first kind, the article, after the silver has been removed by the process described below, may be rendered smooth with water-of-Ayr stone previous to being replated; but if the metal itself has been blistered when the burnisher was applied to it, the blisters must be scraped, buffed, or filed down, and the surface made smooth in the ordinary way.

The silver is removed (or "stripped") from articles thus:—Put some strong sulphuric acid into a stone jar or enameled saucepan, and add a few crystals of nitrate of potassa (saltpetre). Apply heat until the nitrate is dissolved. When this solution is very hot the articles are to be immersed, and occasionally moved about until the silver becomes entirely dissolved from the surface. The removal of the silver will become manifest by the metal beneath being exposed at the edges. The operation must then be closely watched in order to prevent the articles remaining longer in the solution than is absolutely necessary. If the above solution does not remove the silver quickly, more nitrate of potassa must be added from time to time, and the heat augmented if required.

When a quantity of things have been stripped in the solution it will begin to work slowly, and a mass of crystals will be found at the bottom of the vessel as it cools. It will be better now to add a quantity of cold water to the solution, and to immerse in it some pieces of zinc, which will throw down the silver in a metallic state, but in minute crystals of a greyish colour. By dropping a little hydrochloric acid into the solution the operator will be able to judge whether all the silver is deposited or not. The acid will form a white precipitate so long as there is any silver in solution. When all the silver is precipitated, the supernatant liquor may be poured off carefully and fresh water added to wash the precipitate, which process should be repeated several times in order to render the silver as clean as possible. The pieces of zinc should be removed before the final washing of the silver. The silver may now be dried and put into a crucible (being previously mixed with a little *dry* powdered potash), and heated in a furnace until all the metal is gathered into a button. During the process of fusion, a few crystals of nitrate of potash may be carefully dropped into the crucible. The silver thus obtained will be perfectly fine.

Or the silver may be precipitated from the *stripping* solution by means of common salt, when chloride of silver will be formed, which may be dried and fused in the same way as above, previously being mixed with a little soda or potassa, to form a flux.

The articles may be stripped in the plating bath, by suspending them in the place of the anode, but this plan is apt to injure the solution, by imparting to it a portion of the copper or other metal of which the article was made. Or the silver may thus be precipitated upon the end of a wire, enclosed in a linen bag to collect the small granules of silver which will fall from the end of the wire. A powerful current would strip the silver off in a very short time. A small quantity of solution containing excess of cyanide should be kept for this purpose alone.

Deposition of Silver upon Non-Metallic Substances.—Silver may be deposited in the same way as copper by the electrotype process, but as cyanide of potassium rapidly dissolves wax, it will not be advisable to employ moulds made of that material. Gutta percha is better, but even this substance is acted upon by cyanide of potassium. Moulds made of fusible metal are, however, more suitable for this purpose. When the cyanide solution of silver is employed for depositing upon or for copying non-metallic substances, the bath should have at least six times as much silver as that required for the ordinary process of plating.

A solution of nitrate of silver, if not too strong, will answer well for depositing upon plumbagoed surfaces, but this solution must not be employed for depositing upon copper or other metallic surfaces.

The backs of copper moulds which are to be coated with silver should be covered with some material to prevent the silver being deposited on those surfaces; for this purpose it has been recommended to boil a little pitch in a strong solution of potassa, which will form a sediment. Some of this sediment is added to a quantity of melted pitch, at which time a violent action ensues, white fumes being evolved. Allow this action to subside, and the resulting material will be ready for use. Melted gutta percha will also answer tolerably well for protecting the backs of metallic moulds.

There are many other practical points in the electro-deposition of silver, which we deem it advisable, for the reader's convenience, to give in the form of an Appendix at the end of this work, to which he will prudently refer when desirous of practising the art of electroplating, &c.

ELECTRO-DEPOSITION OF GOLD.

In importance, electro-gilding is second only to the art of electro-plating; and it is carried on in much the same way. The solutions of gold, however, should be generally worked *hot;* hence the operation of gilding is conducted in a much shorter space of time than is required for plating. An article may be well and strongly coated in a few minutes, whilst it would require several hours to electro-plate an article well.

There are many forms of solution in use amongst electro-metallurgists, all of them varying in the proportion of gold to the gallon of water, and in the amount of cyanide employed. These solutions are all of them easily made, and any of them can be well worked by a skilful operator. Some gilders use five or six pennyweights of gold to the quart of solution—others as much as eight or ten dwts.; but I have generally found that a solution containing less gold will give better results than one richer in the metal, independent of the advantage in point of economy. I have observed that a bath containing five or six dwts. of gold to the quart of water, and the necessary proportion of cyanide, and worked with several united cells of Smee's battery, has required a much larger surface of anode to be exposed to a given surface of negative electrode (that is, the article to be gilt) than would be required to gild an article in a solution containing one and a half dwt. to the quart of solution worked with a single cell of a constant battery. Hence I infer that the weaker solution is the better conductor of the two.

Gold Solutions.—Solution I.—Dissolve in a Florence flask one pennyweight and a half of fine gold in two parts hydrochloric acid and one part nitric acid (*aqua regia*), applying gentle heat to accelerate chemical action. When the gold is all dissolved, pour the chloride of gold thus formed into a porcelain capsule and apply moderate heat until all the acid is evaporated. A red mass will result. It is advisable, when the acid is nearly expelled, to move the capsule round and round, so that the liquid may be dispersed over a large surface of the vessel. It will be found that the liquid will cease to flow when the acid is expelled, at which period the operation is complete. If too much heat is applied the gold will become reduced to the metallic state, which may be known by the red mass acquiring first a yellow tinge, and next a gold bronze will be observed at the bottom of the capsule. In such a case it will be necessary to add a little more of the mixed acids in the same proportion as before, which will at once redissolve the reduced gold.

When the acid has been driven off the chloride of gold, about half a pint of cold distilled water is to be added, which will at once dissolve the chloride, forming a bright straw-coloured solution. Allow this to subside for a few minutes, as in all probability there will be a small amount of white precipitate at the bottom of the vessel, which is chloride of silver; the solution of gold must be carefully poured off from this precipitate, as it is soluble in cyanide of potassium, and its presence in the resulting solution may be prejudicial. A little distilled water may be poured into the capsule, to rinse away all the gold, taking care not to allow the sediment to come away with it, when transferring the rinsings to the solution of gold.

A little strong solution of cyanide is now added, gradually, to the solution of gold, and the whole stirred with a glass rod. The gold solution will instantly lose its yellow colour. A brown precipitate is formed by the solution of cyanide, and this solution must be added drop by drop until it produces no further effect upon the clear solution. The supernatant liquor is now to be carefully poured off, and fresh water added several times to wash the precipitate of gold—taking care not to waste any of the precipitate nor to add more cyanide than is *absolutely* necessary. When the precipitate is sufficiently washed, more of the solution of cyanide is added, which will at once dissolve the precipitate, forming a clear solution. The cyanide should be added in excess, say about twice as much as may be required to dissolve the precipitate. The concentrated solution of cyanide of gold thus obtained is placed over the fire or on a sand-bath until it is evaporated to dryness, when it may be again dissolved in cold water and filtered for use. Lastly, enough boiling distilled water is added to make one quart of solution, and a little additional cyanide added if the solution is found to work too slowly at first—but it is better not to use more cyanide than is necessary, otherwise the anode will become rapidly consumed and the gilding be of a "foxy" colour.

Solution II. Dissolve one and a half dwt. fine gold as before, and evaporate to dryness. Re-dissolve in half a pint of distilled water and precipitate the gold with ammonia, taking care not to add more ammonia than is necessary. Pour off the supernatant liquor and wash the precipitate as before. Now add sufficient cyanide of potassium to dissolve the precipitate. Evaporate to dryness, and re-dissolve with cold distilled water. The solution is then to be filtered, and distilled water added to make one quart. A little cyanide is to be added occasionally, as required.

Solution III. Dissolve one dwt. and a half as before, and when the half pint of solution of chloride is obtained, precipitate the gold with hydrosulphate of ammonia. A copious black precipitate is formed, which must be allowed to subside, and this substance then washed as before directed. Dissolve the precipitate with a lump of cyanide—say about half an ounce, or rather less; and evaporate to dryness. Then add water to make one quart.

Solution IV. Dissolve the same quantity of gold as before, but without evaporating the acid. Add a quantity of calcined magnesia, which will precipitate the gold in the form of an oxide. To the oxide add sufficient concentrated nitric acid (applying heat at the same time) to dissolve the magnesia, when the oxide will be left in the form of a precipitate, which is to be well washed, and then solution of cyanide added to dissolve it as before. Evaporate and make one quart of solution with distilled water.

Solution V. Dissolve one ounce of cyanide of potassium in one quart of nearly boiling distilled water. About half fill a "porous cell" with the solution, and stand it in the vessel containing the bulk of the solution. Attach a piece of sheet copper to the wire issuing from the zinc of the battery, and place it in the porous cell. Put a piece of sheet gold, attached to the copper of the battery by a wire, in the outer solution, and allow the whole to remain in action until the solution has acquired about one pennyweight and a half of gold, which may be ascertained by weighing the gold before and after immersion. The porous cell may now be removed and its contents thrown away. The solution is now ready for use.

These solutions should be worked at a temperature of about 130° F., with one cell of a constant battery.

The solution of gold may be heated either in an enameled saucepan, or in a glass vessel placed in an iron pan containing water. The operator now proceeds to arrange his battery. The wire which issues from the copper of the battery is to be attached to a piece of fine gold, which may conveniently be done by soldering. The article to be gilt is to be suspended to the wire proceeding from the zinc of the battery.

Preparation of Articles to be Gilt.—Silver goods, such as cream ewers, sugar bowls, mugs, &c., should be well scoured inside with hot soap and water and silver sand, and if they are at all greasy, a little caustic soda may be applied to them first. Or the mugs, &c., may be well scratch-brushed and then rinsed with boiling water. The insides only of these vessels are generally required to be gilt, in which case the outsides may be wiped dry before gilding. The negative wire (from the zinc of the battery) is to be attached to the handle of the vessel. The plate of gold is now to be carefully suspended in the centre of the mug, taking care that it does not touch the vessel; and the gold solution may be poured into the mug by means of a jug or other suitable vessel, until it reaches the upper edge. If it is desired to gild the extreme edge, the solution may be guided over it with a piece of wood or glass rod. In about five or six minutes the vessel will be sufficiently gilt, when the anode may be removed, the negative wire detached, and the solution poured into the bath. The article is at once to be rinsed with hot water, and may be scratch-brushed and burnished in the ordinary way. When cream ewers, &c., are so constructed that the solution will not reach the lip, &c., without overflowing, it is advisable to slightly tilt the vessel so as to cover as much of it as possible, and when it is gilt the lip may be dipped into a little gold solution, being attached to the battery the while; but in this case the outside of the lip will also receive a deposit. This may be prevented by coating the outer surface of the vessel with the composition which we have already described, p. 59. Vessels which are to be gilt inside only, should be placed on a plate or dish to collect any solution which may run over.

Silver brooches, pins, rings, thimbles, egg, salt and mustard spoons, &c., merely require to be scratch-brushed before gilding. After they have received the required deposit, they are again brushed, and if the colour be a little too pale or too red, the articles should be immersed in the bath again *for an instant*, and then plunged into boiling water, when they will assume a beautiful fine gold colour. When well rinsed in hot water, the articles are to be placed in box saw-dust, which may sometimes be advantageously kept hot for this purpose, in order to dry the goods as speedily as possible; but care must be taken that the box-dust be not allowed to char or burn, otherwise it will stain the articles.

Goods which are made of copper or brass entirely, may be dipped into nitrous acid ("fuming nitric acid" or "dipping acid") for a moment, and instantly plunged into clean cold water; after which process they should be again rinsed in fresh water, and at once placed in the gilding bath. Or such articles may be merely scratch-brushed, rinsed, and then placed in the bath.

If, when first put in the bath, copper or brass goods receive the deposit too quickly, the anode should be raised a little out of the solution, so as to expose a smaller surface, and the articles should be moved about a little, by which uniformity of deposit will be secured. In fact, it is advisable always to give the articles a gentle motion when first placed in the bath, until they have received a slight coating, when they may be allowed to remain steady until finished; but when it is required to deposit a stout coating, it will be advantageous to move them occasionally, to prevent the deposit taking *place unevenly*.

When goods are made of either copper or brass, with mountings of another metal, or if they have been previously plated or gilt, greater care must be observed, otherwise some parts will receive the deposit favourably while others will scarcely be coated at all. This applies more especially to goods which have mountings pewter-soldered upon them, which is frequently the case in common jewellery. In this case all the surfaces will receive the deposit but the solder, which, being a bad conductor of electricity, and more electro-negative than the other metal to which it is attached, will receive the deposit but tardily, if at all. I have frequently found that the smallest speck of pewter solder which has happened to be upon a brooch which I had to gild, has compelled me to deposit at least three times as much gold as the article required before I could cover the speck of solder; and in many instances not even then would deposit take place upon the offending spot. Having tried to amalgamate the solder with the gilt surface by means of nitrate of mercury, nitrate of silver, and both combined and alternately applied; and having scratch-brushed the tardy spot until I was heartily sick of pewter solder and everything which it contaminated, I at last hit upon a plan by means of which I have ever since been enabled to gild pewter solder with ease and certainty. I placed a single drop of an acid solution of sulphate of copper upon the solder spot, and then touched it with a piece of steel: in an instant the solder and surrounding surface received a bright deposit of copper (which could be strengthened by repeating the operation several times). The moment the article was placed in the gilding bath the spot became coated; in fact—copper being easier to gild than gold—this spot received the deposit in preference, so that my difficulty was speedily and satisfactorily overcome. Many electro-gilders, I have no doubt, will find the above plan relieve them from a considerable amount of annoyance. Generally speaking, however, when the operator finds a difficulty in gilding pewter solder, it is owing to the bath requiring cyanide, or the exposure of a larger surface of anode; or may be the battery power is weak.

Instead of the above plan of coating pewter solder, the manipulator may put a drop of concentrated solution of silver upon the solder, as before, and, on touching the part with a piece of fine wire the solder will be coated with silver in an instant. I prefer the former plan, however, since copper receives the deposit of gold more readily than silver.

In gilding cheap jewellery, French and Birmingham fancy goods, and articles which are not required to have more than a *coloured surface* given to them, I have found it an economical plan to gild with a copper anode, and as the gold becomes exhausted from the solution, to add more gold from time to time, thus working from the solution instead of from the anode. By this arrangement, the operator is sure not to deposit more gold upon his work than is consistent with the scale of remuneration for doing the same.

Generally, it is only necessary to scratch-brush this class of goods; then having rinsed them in boiling water, they are to be dipped into the solution for an instant; a few seconds only being required to give the goods a beautiful colour.

Silver filigree brooches, &c., must be well scratched, dipped in the bath for a moment and then rinsed and scratched again: on immersion in the bath the second time they will become more uniformly gilt. The surface of anode must be adequate and the battery power brisk, or the filigree work will not receive the deposit uniformly. The solder of filigree work is generally the most troublesome to gild, but if the current and other circumstances are favourable, the deposit should take place all over at once; a want of cyanide in the solution is a principal cause of difficulty in gilding filigree work. Gently moving the articles about in the solution, greatly adds to the beauty and uniformity of the result, if all other matters are favourable. The solution for gilding filigree goods should contain rather more gold than that for ordinary work, and the surface of anode exposed must be greater.

Metal pins, brooches, rings, &c., should be either "dipped" as before recommended, or well scratch-brushed before gilding. This class of goods may be done on a large scale, in a porcelain vessel like a colander, suspended in the bath. The goods, being placed in this, merely require to be touched, and occasionally stirred about by the negative pole of the battery, so as to cover those parts which have been in contact with each other.

Army accoutrement work, sword-mountings, &c., should first be prepared by cleaning with silver sand, soap and water, applied with a hard brush. The article may then be scratch-brushed, and placed in the bath until it has *nearly* acquired a sufficient coating, when it is to be removed, rinsed in warm water, and those parts which are required to be left *dead*, gently brushed over with powdered pumice or Bath-brick. The article is then returned to the bath and allowed to remain until finished. As soon as it has become sufficiently gilt, the plain surfaces may be scratch-brushed, and then burnished.

I have induced my workpeople to burnish gilt-work with four-penny ale, instead of soap and water, and it has been considered by them a great improvement, since the burnisher seems to glide over the surface of the work with greater ease and smoothness, more especially when the gilding has been what is termed "hard" or "scratchy." Vinegar has sometimes been applied to this purpose, but not, I think, with such success.

In gilding German silver, the solution may be worked at rather a lower temperature, the solution weakened, and a less surface of anode exposed. German silver has the power of reducing gold from its solution in cyanide (especially if the solution be strong) without the aid of the battery; as also will brass receive a coating of silver in the plating-bath without the use of the current, therefore the solution should be weaker—in fact, so weak that the German silver will not deposit the gold *per se*; otherwise the deposit will take place so rapidly that the gold will peel off when being burnished, or even scratch-brushed.

When iron or steel goods are to be gilt, they should be first rendered free from grease, by being immersed in a solution of caustic soda or potassa; they are then to be well scratch-brushed—in fact, until they have acquired a slight coating of brass, from the wires of the brush. If sour beer is used for this purpose it will greatly facilitate the operation. The article should then be placed in the bath for an instant, then well scratch-brushed and dipped again. The solution employed for iron or steel should be much weaker than for any other metal. I would recommend the following:—

Ordinary solution	4 fluid ounces.
Water	20 „
Cyanide of potassium, about . . .	2 drachms.

This solution may be worked rather warm, but not so hot as the ordinary solution. Weak battery power should be employed, and small surface of anode, and deposition must be allowed to take place very slowly at first.

By scratch-brushing iron or steel articles with vinegar or dilute hydrochloric acid, a very good and adhesive coating of copper may be obtained upon the surface of the article, but the employment of the latter must be done with caution or the operator's clothes may be injured; a few drops of acid, however, to the pint of water is all that will be required.

The best method of preparing steel or iron articles for gilding, is to coat them with copper or brass in the same way as that recommended for plating these metals. Many steel articles, which only require a trifling deposit of gold, may be gilt without any further preparation than merely rinsing them in hot water. The articles then receive a momentary dip in the bath, and, being sufficiently gilt, are rinsed in hot water and dried quickly in hot box-dust, or in an oven.

Steel surgical instruments must be gilt with great care, in order that the edges be not rendered blunt by the operation. These articles should be placed in the bath without any preparation, as coating them with copper or brass, and then gold, may involve too much handling. A slight deposit is all that is necessary to protect the steel instrument from rust or corrosion.

Steel or iron keys should be first well scratch-brushed, dipped into the bath for a moment, and then brushed again; lastly, allowing them to remain in the bath until sufficiently coated. These may be finished either by burnishing or polishing.

ELECTRO-DEPOSITION OF BRASS AND BRONZE.

It is far more difficult to deposit an alloy of two or more metals than one only; and this difficulty becomes greater when we require to deposit, as an uniform alloy, two metals whose electrical conditions are of an opposite character, as zinc and copper. From a solution consisting of zinc and copper in the proportions to form ordinary brass, it is easy to deposit the zinc alone, or the copper alone, by increasing or diminishing the power of the current, or by raising or lowering the anode; that is to say, by increasing or diminishing the surface of anode exposed to a given surface of object to be coated.

The difficulty in regulating all circumstances, so that an uniform result might be obtained by the operator, and so that the process of electro-brassing might be depended upon, has, in many instances, caused this useful art to be abandoned altogether by the manufacturer.

Many processes of electro-brassing have been published and patented in this country and on the continent, but all of them have the disadvantage of being more or less troublesome and uncertain to manage, even though the operator be a person well skilled in electro-deposition. But I think that several of these processes may be rendered commercially valuable if the solutions in the first instance are mixed by persons acquainted with chemical laws. Again, there would be less liability to failure. if the power of the current employed was always regulated by the surface of goods to be coated; the amount of anode, also, being regulated by the same. If, on the contrary the battery-power be too weak, or in excess, either the copper on the one hand, or the zinc on the other, will be deposited alone.

In giving the various processes of electro-brassing, I may inform the reader that several of them are patented, and consequently cannot be employed for commercial purposes without the permission of the respective patentees.

I. De Salzede's Patent Processes.

I.

Cyanide of potassium	12 parts.
Carbonate of potassa	610 ,,
Sulphate of zinc	48 ,,
Chloride of copper	25 ,,
Nitrate of ammonia	305 ,,
Water	5000 ,,

Dissolve the cyanide of potassium in 120 parts of the quantity of water above specified, and then dissolve the carbonate of potassa, sulphate of zinc, and chloride of copper in the remaining water, raising the temperature to about 150° F.; and as soon as the salts are well dissolved add the nitrate of ammonia, frequently stirring until the latter is dissolved. The solution may now be allowed to stand for a few days, in order that the sediment formed may become precipitated, when the clear liquor is to be drawn off, and is ready for use.

II.

Cyanide of potassium	50 parts.
Carbonate of potassa	500 ,,
Sulphate of zinc	35 ,,
Chloride of copper	15 ,,
Water	5000 ,,

This solution may be made up in the same way as No. 1.

3. Bronzing solution.

This solution is the same as No. 1, excepting that 25 parts of chloride of tin are used instead of the sulphate of zinc.

4. Bronzing solution.

In this solution 12 parts of chloride of tin are employed instead of sulphate of zinc in the second brassing solution. This latter solution Salzede works at a temperature not exceeding 97° F.

The above solutions are to be worked with a brass anode, and with an active battery of two or more cells —Bunsen's battery being preferable to any other. The current of electricity employed in electro-brassing must have a brisk intensity—the quantity also being considerable.

The above solutions work very well at first, but they soon get out of order, owing to the irregular action of the cyanide upon the brass anodes, which readily attacks the copper, whilst the zinc frequently remains upon the surface of the anode in the form of a white paste. Hence the character of the solution soon becomes altered.

II. Brass Solution.

Acetate of copper	5 ounces.
Potassa	4½ pounds.
Sulphate of zinc	10 ounces.
Liquid ammonia	1 quart.
Cyanide of potassium	8 ounces.

Dissolve the acetate of copper, which should be previously pulverised, in half a gallon of water. Add 1 pint of the liquid ammonia, and then dissolve the sulphate of zinc in 1 gallon of water, the temperature of which should be raised to about 180° F. When the zinc is dissolved, add the remaining pint of liquid ammonia to the solution, which should be well stirred immediately, in order to insure its perfect mixture with the sulphate of zinc.

Dissolve the potash in one gallon of water. Lastly, dissolve the cyanide of potassium in one gallon of hot water, and then mix the ingredients in the following order:—The solution of copper to be added to that of zinc; now add the solution of potash and cyanide. Stir the whole well together, and allow the mixture to digest for an hour or so, stirring occasionally. Add water to make altogether 8 gallons of solution.

The above solution must be worked with active battery-power and a brass anode—milled brass being preferable. The anode should be well cleaned before immersion. A little liquid ammonia may be added from time to time, and also a small portion of cyanide when the solution works slowly. The anode must be kept clean. I have also found it advantageous to add a little arsenious acid to the solution, which improved the character of the deposit, by rendering it brighter and less crystalline. The arsenious acid, however, does not at first appear to make much difference, but after a while the improvement becomes manifest. I generally apply the arsenic by mixing it with a strong solution of cyanide of potassium. About one ounce to the above solution will be sufficient at first, and the quantity may be increased by degrees.

III.

Acetate of copper	10 pounds.
,, zinc	1 pound.
,, potassa	10 pounds.

Dissolve the above substances in 5 gallons of hot water, and add cyanide until a precipitate is formed, which, upon adding more cyanide, becomes again dissolved. An excess of cyanide must be added. The patentees of this process (Messrs. Russell & Woolrich) use either a brass anode, or one of brass and another of copper at the same time.

IV. Bronze Solution of M. Brunel & Co.

Chloride of copper	1 pound.
Carbonate of potassa	25 pounds.
Sulphate of zinc	2 ,,
Nitrate of ammonia	12½ ,,

The chloride is to be dissolved in half a gallon of water; the carbonate of potassa in 6 gallons of water; the sulphate of zinc is to be dissolved in half a gallon of hot water. These three solutions are to be mixed together. Now add the nitrate of ammonia, and blend them all together by stirring well for a few minutes. Make about twenty gallons, by adding cold water.

This solution is to be worked in the same way as either of the above.

The above solution much resembles M. Salzede's process, and is prone to get out of order owing to the fact that the anode does not supply the solution with metal as fast as it is deprived of it by the articles coated. Unless the solvent employed will readily attack and dissolve the zinc of the anode, the solution must soon lose its proportion of this metal. The liquid ammonia used in one of the above processes seems to effect this more satisfactorily than an excess of cyanide. I have invariably found that in any of the above processes, the employment of a liberal amount of liquid ammonia has kept the anodes clean, and enabled the solution to give better results in every respect. The white salt of zinc formed upon the surface of the anode is soluble in this menstruum, but sparingly so in cyanide of potassium. The ammonia and cyanide being in the solution in abundance, will keep the anode clean, without which the action soon ceases altogether.

V. Newton's Process consists in forming solutions for depositing alloys of copper, tin and zinc, and also, for depositing brass and bronze.

The patentee mixes chloride of zinc with chloride of ammonium, sodium, or potassium dissolved in water.

Acetate of zinc in solution mixed with acetate of ammonia, potassa, or soda.

In making up a brassing solution, Newton adds to either of the above solutions a proportion of a corresponding salt of copper—for instance, with the acetate of zinc he would unite the acetate of copper, and so on. He employs various other salts of zinc, with the corresponding copper salt, for the same purpose.

In making a bronzing solution Mr. Newton dissolves the double tartrate of copper and potassa, and double tartrate of the protoxide of tin and potassa, with or without the addition of caustic potassa. He deposits an alloy of zinc, tin and copper, by using a solution composed of the following substances:—double cyanide of copper and potassium; zincate of potassa and stannate of potassa; the zincate of potassa he forms by fusing oxide of zinc with caustic potassa, and the stannate of potassa either by fusing oxide of tin with caustic potassa, or by dissolving it in a solution of potassa.

For an electro-brassing solution the patentee employs a solution composed of a given quantity of oxide of copper, dissolved in an excess of cyanide of potassium;

oxide of zinc and a little liquid ammonia are then added, and the solution heated to 120° Fah., to 140° Fah. Water is then added, in sufficient quantity to allow the solution to contain about 3 oz. of the oxides to the gallon—*i. e.*, 2 of zinc to 1 of copper to form brass.

VI. Brassing Solutions.

I.

Cyanide of potassium	1 pound.
Carbonate of ammonia	1 ,,
Cyanide of copper	2 ounces.
,, zinc	1 ounce.

Dissolve in one gallon of water. The temperature to be raised to 150° Fah.

II.

Cyanide of potassium	1 pound.
Carbonate of ammonia	1 ,,

Dissolve in one gallon of water. Attach a large brass anode to the positive wire of a battery, and apply a small surface of cathode or negative electrode—say a strip of brass. The temperature should also be 150° Fah. By this arrangement the anode dissolves, supplying the solution with metal. The exact quantity which the solution has taken up may be ascertained by weighing the anode before and after immersion.

VII. Brunel gives another formula for a brassing solution :—

Carbonate of potassa	10 pounds.
Cyanide of potassium	1½ pound.
Sulphate of zinc.	1¼ ,,
Chloride of copper	10 ounces.
Water	12½ gallons.

The best way of making up the above solution is to dissolve all the ingredients in separate vessels ; then to add to the sulphate of zinc and chloride of copper a portion of the solution of carbonate of potassa. Now add sufficient liquid ammonia to dissolve the respective precipitates at first formed, when the solution of cyanide and the remainder of the carbonate of potassa may be poured in, and water added to make altogether 12½ gallons. This solution must be worked with a large brass anode, and a brisk battery of two or more Bunsen's cells. The solution should stand for some hours before using it, when it may be separated from any sediment which may remain at the bottom of the vessel in which it is made.

The above solution will require to be replenished from time to time with a little cyanide of potassium and liquid ammonia, in order to keep the anode free from the white salt of zinc, which would otherwise form upon its surface. Arsenious acid improves this solution; and I have found that a little chloride of tin, dissolved in caustic potassa, tends to toughen the deposit.

Iron, lead, zinc, tin, and alloys of lead, &c., will not all receive an equally good coating of brass if placed in the bath at the same time. No two metals of different characters should be immersed together; and, indeed, different solutions should be employed for each metal or alloy.

Cast iron requires a solution containing a greater per-centage of metal than zinc or its alloys; whilst zinc will receive a good deposit when but little metal is in the bath. Lead also requires to be coated in a bath which is richer in the metals.

In immersing in the bath two different metals, as cast-iron and zinc for instance, the zinc would receive the deposit at once, whilst the iron would not receive the smallest amount of deposit, and in striving to force the metal on the iron surface the operator may impair his solution. Even cast- and wrought-iron require to be coated in different baths. By observing this rule, the solutions are not so liable to get out of order.

Again, iron and zinc require different degrees of battery-power to effect a good deposit upon them. A battery which would coat zinc well would not cause the least deposit to take place upon cast-iron.

Electro-brassing Cast-iron work.—In preparing cast-iron work for the brassing bath, it will be necessary first to make up a "pickle" of the following:—

Sulphuric acid	1 pound.
Water	20 pounds.

The article is placed in the pickle, and allowed to remain until the oxide of iron has become loosened from the surface of the article, in other words, until a brush and sand will easily remove the oxide. If at any time the oxide is found to adhere firmly to the cast-iron surface, the pickling process must be continued until it yields readily to the brush.

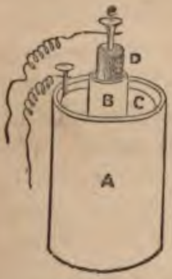
When the work is very rusty, it may be first placed in a pickle composed of—

Hydrochloric acid	1 pound.
Water	20 pounds.

and any parts which may have a thick coating of rust may be cleaned by applying strong hydrochloric acid to the part, which readily dissolves the rust. It is better to remove the rust, as suggested, before immersing the whole article in the first pickle. Generally speaking, from an hour to an hour and a half is sufficient time to remove the oxide of iron in the pickling bath.

As soon as the articles are pickled, they are to be well rinsed, and are then to be laid on a board, placed over a vessel of water, called the "cleaning-board," and are to be thoroughly cleaned with a hard brush, sand, and water until the oxide is completely removed. The article is then to be rinsed in clean water, and may be placed in a weak solution of potash or soda. It is now ready for the bath, in which it may be suspended by a stout copper wire connected with the negative electrode of the battery.

For most purposes I prefer using two cells of a Bunsen's battery, consisting each of a cylindrical stone jar A fitted with a cylinder of zinc, C, which must be well amalgamated and a copper wire attached to it. A porous cell B is placed in the centre, and a bar of carbon D is put into the cell, which is then filled with concentrated nitric acid. Into the outer cell is poured a solution of sulphuric acid, consisting of about 1 part of acid to 20 of water. A binding-screw is attached to the carbon, and a stout copper wire, which is to be soldered to a brass anode.



When the article has been immersed in the solution for a few minutes, a white foam will show itself at the point of the wire, in most instances, and frequently bubbles of gas will be seen to rise in various parts of the solution. In electro-brassing, generally, but little deposition takes place unless there is the evidence of chemical action alluded to.

As soon as the article has received the required coating—which, for ordinary purposes, may be accomplished in about two hours, with two cells of the battery just described, holding about four gallons in each jar—it is to be at once rinsed in hot water and then placed in hot saw-dust. For this purpose mahogany saw-dust answers very well. When thoroughly dry, if it is required to bronze it, the article should be rubbed over with a leather and a little powdered pumice or whitening, in order to brighten those surfaces which are to look bright when the work is complete. Instead of bronzing it, the article may be cleaned and lacquered. The bronzing process is described at page 37.

Electro-brassing Wrought Ironwork.—It is more easy to electro-brass wrought than cast ironwork, as it is less porous, and is in general much more smooth. The goods may be first pickled in the sulphuric acid pickle-bath, and then cleaned with a brush, sand, and water. The solution in which wrought ironwork is brassed need not contain quite so much metal as that for cast iron, and it generally does not require the exposure of so great a surface of anode.

When the goods are placed in the bath, if the deposit appears of too red a hue, rather more anode must be exposed; if, on the other hand, the work is pale, less of the anode should be immersed. The surface of anode will generally regulate the colour of the deposit. Wrought iron receives the deposit more readily than cast iron, consequently it need not remain in the bath quite so long as the latter.

Electro-brassing Articles of Zinc.—Goods of this description should first be placed for a quarter of an hour or so in a pickle consisting of:

Sulphuric acid	1 ounce.
Hydrochloric acid	2 ounces.
Water	1 gallon.

The articles may then be rinsed in clean cold water, and, being placed on the cleaning board, they should be scoured well with a hard brush, sand, and water. Zinc goods, if the battery and bath are in good working order, will receive the deposit immediately on being immersed in the bath; when the reverse is the case, however, either the solution is deficient in conducting power—in which case add fresh cyanide and liquid ammonia—the battery is weak, or the surface of anode must be increased. The goods, when sufficiently coated, are to be rinsed in hot water, and then placed in hot mahogany saw-dust; it is important that the articles should be well rinsed. This class of work may be bronzed or polished and lacquered.

Electro-brassing Lead and Pewter Articles.—Lead does not receive the deposit so favourably as zinc, but pewter receives it tolerably well. They may, however, be both coated in the same bath without harm. Lead should be pickled in a dilute solution of nitric acid, say a mixture containing about four ounces of nitric acid to the gallon of water. The same pickle will do for pewter work. The goods may remain in the pickle for half an hour, when they are to be well rinsed and scoured with sand as before; lastly, rinsing in clean water. A good surface of anode should be exposed, more especially when the articles are first put into the bath. If the battery power is not ample, lead is very apt to become coated *in parts*, owing to its being a very indifferent conductor of the current.

In brassing lead and pewter, it is advisable to raise the temperature of the bath to about 90° Fahr., when this can be done conveniently. The same observation applies to coating tin with brass.

When a brassing solution has been worked for some time, it is liable to deposit either copper or zinc only—generally speaking the former. The principal cause of this is that the solution has not the power of dissolving the brass anode equally, the copper in the alloy being readily attacked by the cyanide and consequently entering the solution, whilst the zinc, being liable to be converted into an almost insoluble salt, either remains on the anode in the form of a white mass, or falls to the bottom of the bath, but a small portion of it entering the solution; consequently the latter, instead of depositing the yellow alloy, deposits only, or chiefly, copper. When the bath is thus found to work unfavourably, it will be necessary to add a little more concentrated solution of zinc; but sometimes I have found that the addition of a large quantity of liquid ammonia to the bath has dissolved a considerable portion of the zinc precipitate from the anode and from the bottom of the vessel, and thus the bath has become restored to its proper condition. When adding the liquid ammonia—which should be the strongest which is made—it is as well to add a little additional cyanide.

The bath may also be restored by separating the clear solution from the precipitate which has fallen to the bottom of the vessel, and by then treating the latter with liquid ammonia and cyanide, which will dissolve the greater portion of it. This is the best plan when it is practicable. The solution thus formed may be added to the bulk of the solution, which will then work well again. Therefore, whenever the anode assumes the white appearance referred to, liquid ammonia or cyanide, or both, must be added, otherwise copper only will be deposited.

Sometimes the bath will become deprived of both zinc and copper, in consequence of the anode not keeping up the supply in the solution. When this is the case, a strong solution of brass should be added to the bath: in fact, a supply of concentrated brass solution should always be kept on hand to be thus employed in case of emergency, for the best solutions are apt to become deprived of metal after being worked a good deal.

Electro-deposition of Platinum.—A solution of platinum may be made by dissolving a piece of the metal in two parts of hydrochloric acid and one part nitric acid, over a sand bath. The acids must both be very strong, or the metal will not yield to their action. When the platinum is dissolved, the acid should be expelled in the same way as that recommended in forming the chloride of gold. A reddish mass will be obtained, which is the chloride of platinum. A little distilled water is now added to dissolve the chloride, into which put a small lump of cyanide, which will at first precipitate and then re-dissolve the platinum. The solution should have about five dwts. of metal to the quart. In working it, the solution should be warm. It is better, however, to filter before using the platinum solution, to remove the impurities with which the cyanide is contaminated.

The battery power employed for depositing platinum should be rather weak, or the metal will be thrown down in the form of a black powder, possessing but little resemblance to the metal itself.

As a platinum anode will not be acted upon by the cyanide, the solution will, of course, soon yield the metal of which it was composed; therefore, it will be necessary, from time to time, to add fresh chloride of platinum to keep it in working order. If it is desired to coat an article strongly with platinum, it will be necessary to keep on adding chloride of platinum to the solution every now and then while deposition is going on, until the object is accomplished. This of course renders the process of electro-platinising not only expensive but tedious; and, for general purposes, impracticable. The cyanide will hold but a small quantity of platinum in solution.

Palladium may be somewhat more readily deposited from its solution than platinum. The metal is to be dissolved in nitro-hydrochloric acid in the same way as above. The solution is next to be treated with cyanide, which will precipitate the metal, and finally re-dissolve it. The solution may be worked warm.

The palladium anode will be acted upon by the cyanide, consequently the operator may deposit the metal to any desirable extent. There is, however, but little importance attached to the deposition of this metal.

Lead.—A solution of lead for the purposes of electro-deposition, may be formed by dissolving the acetate or nitrate of lead in water. By employing the solution in a rather weak state, with moderate battery power, lead may be deposited with ease, but the deposit from these acid solutions is of a very indifferent quality. An alkaline solution may be made by precipitating the lead from either of the above solutions, either with soda, potassa, or ammonia, and then re-dissolving with cyanide, but the solution is only fit for experimental purposes.

Electro-deposition of Nickel.—Since the first publication of this work, the deposition of nickel has become an important branch of the electro-metallurgic art; and, doubtless, the credit of its extensive development is due in a great measure to Mr. Adams, of Boston, Massachusetts, whose patent, dated October 28, 1869, was purchased, and is now being extensively worked, by the "Plating Company, Limited." Mr. Adams, taking advantage of the valuable suggestion of M. Boettger, published in 1843, employs the double sulphates of nickel and ammonium, and the double chlorides of nickel and ammonium in forming his solution-baths.

The following abstracts from Mr. Adams' specification will be interesting to those who desire to become acquainted with the deposition of this useful metal:—

"It has long been well known that nickel possesses certain qualities which render it of great value in the arts, if it could be readily and surely deposited by the battery in such a manner as to make these qualities available. These qualities are, first, infusibility; second, its colour, which is nearly that of silver; third, its hardness, which is nearly equal to that of steel, and by reason of which it resists wear and abrasion to a much greater degree than silver; fourth, its power of resisting oxidation, and the tarnishing and corrosive effects of many gases and liquids. The two last-named qualities render it, for many purposes, greatly superior to silver, which it much resembles in appearance, for electro-plating other metals, and for making articles of solid metal. To these advantages should be added its cheapness as compared with silver.

"*The* inventor has discovered the causes of certain difficulties in the practical deposition of this metal, and is able to remove them, and to point out methods of preparing solutions, and the conditions which they must satisfy, and under which they must be used, so that a solid, coherent, tenacious, and flexible nickel can be deposited to any desired amount. He can thus render the electro-deposition of nickel practically valuable, not only for electro-plating upon other metals, but for that branch of the art of electro-deposition known as electrotyping; that is, the deposition of nickel upon a surface, not to remain upon it as a permanent coating, but to be removed and used independently of it."

Mr. Adams thus describes his process for making a solution-bath with the double sulphate of nickel and ammonium:—

"In preparing this solution the inventor prefers to use pure nickel, but commercial nickel may be used. Commercial nickel almost always contains more or less of the reagents employed in the purification or manufacture of the metal, such as sulphate of lime, sulphide of calcium, sulphide of sodium or potassium, chloride of sodium, and alumina. When any of these substances are present, it is necessary to remove them. This can be done by melting the nickel, or by boiling it in water containing at least one per cent. of hydrochloric acid. The boilings must be repeated with fresh acid and water until the wash-waters give no indication of the presence of lime when treated with oxalate of ammonia. When the metal is purified by melting, the foreign substances collect on the top of the melted metal in the form of a slag, which can be removed mechanically. If the nickel contains zinc, it should be melted, in order to volatilize the zinc, and drive it off. The crucible in such case must not be closed so tightly as to prevent the escape of the zinc fumes. If copper, arsenic, or antimony is present in the nickel, it can be removed after the nickel is dissolved, by passing sulphuretted hydrogen through the solution. The acid to be used in dissolving the metal consists of 1 part strong nitric acid, 6 parts muriatic acid, and 1 part water. Nitric acid or muriatic acid may be used separately, but the above is preferred. A quantity of this acid is taken, sufficient to dissolve any given amount of the metal, with as little excess of the former as possible; a gentle heat is all that is required. The resulting solution is then filtered, and to prepare the solution of the double sulphate of nickel and ammonium, a quantity of strong sulphuric acid, sufficient to convert all the metal into sulphate, is added, and the solution is then evaporated to dryness. The mass is then again dissolved in water, and a much smaller quantity than before of sulphuric acid is added, and the whole again evaporated to dryness, the temperature being raised finally to a point not to exceed 650° F. This temperature is to be sustained until no more vapours of sulphuric acid can be detected. The resulting sulphate of nickel is pulverized, and thoroughly mixed with about one fiftieth of its weight of carbonate of ammonia, and the mass again subjected to a gradually-increasing temperature, not to exceed 650° F., until the carbonate of ammonia is entirely evaporated. If any iron is present the most of it will be converted into an insoluble salt, which may be removed by filtration. The resulting dry and neutral sulphate of nickel is then dissolved in *water by boiling*, and, if any insoluble residue remains, the solution is filtered. From the weight of nickel used before solution, the amount of sulphuric acid in the dry sulphate can be calculated. This amount of sulphuric acid is weighed out and diluted with four times its weight of water, and saturated with pure ammonia, or carbonate of ammonia—the former is preferred. This solution, if it is at all alkaline, should be evaporated until it becomes neutral to test-paper. The sulphate of ammonia of commerce may likewise be used, but pure sulphate of ammonia is to be preferred. The two solutions of the sulphate of nickel and sulphate of ammonia are then united, and diluted with sufficient water to leave one and a half to two ounces of nickel to each gallon of solution, and the solution is ready for use. The object of twice evaporating to dryness, and raising the temperature to so high a degree, is, in the first place, to drive off the excess of sulphuric acid; and, secondly, to convert the sulphate of iron, if it exists, into basic sulphate, which is quite insoluble in water.

"In order to give the best results, it is necessary that the solution should be as nearly neutral as possible, and it should in no case be acid. The inventor prefers to use the solution of a specific gravity of about 1,052 (water 1,000), though a much weaker, or still stronger, solution may be used. At temperatures above the ordinary, the solution still gives good results, but is liable to be slowly decomposed. An excess of sulphate of ammonia may be used to dilute the solution in cases where it is desirable to have it contain much less than an ounce of nickel to the gallon.

"In preparing the solution of double chloride of nickel and ammonium, the nickel is to be purified and dissolved in the same manner as is described for the previous solution, and it is to be freed from copper and other foreign matters in the same manner. The solution is then to be evaporated to dryness; it should be made as nearly anhydrous as possible. The salt is then placed in a retort, and heated to a bright red heat. The salt sublimes, and is collected in a suitable receiver, the earthy matter being left behind. The salt thus purified is dissolved in water, and to the solution is added an equivalent quantity of pure chloride of ammonium. The solution is then ready for use; it may have a specific gravity of 1,050 to 1,100."

Another part of Mr. Adams' patent relates to the preparation of the anodes to be used in depositing nickel. He combines iron with nickel in forming the anodes, and by this means he believes that any copper which may be present in the nickel is precipitated by the iron, or becomes deposited upon the anodes, from which it may be removed by scraping. Another motive for adding iron to the nickel is that it renders the latter more readily fusible.

A very simple way of making a solution of nickel for ordinary purposes, and which, with care, will give very good results, is the following :—Take say 2 ounces of pure nickel, dissolve in hydrochloric acid, taking care not to have an excess. A gentle heat will assist the operation. When dissolved, dilute the solution with 1 quart of cold water. Now add ammonia, gradually, until the solution is quite neutral to test-paper. Next, dissolve 1 ounce of sal-ammoniac (chloride of ammonium) in water, and mix this with the former solution. Lastly, add cold water to make 1 gallon of solution.

The double sulphate of nickel and ammonium may be simply formed by dissolving say 2 ounces of nickel in 1 part sulphuric acid, and 2 parts water, a gentle heat being employed until all the metal is dissolved. The solution is to be diluted, and neutralized with ammonia as before. Next take 1 ounce of carbonate of ammonia and dissolve; add to this, carefully, sulphuric acid until the solution ceases to be alkaline to test-paper. It must not, however, be *acid* on any account. This solution of sulphate of ammonia is to be added to the solution of sulphate of nickel, and sufficient cold water added to make one gallon of solution.

Both of these solutions should be filtered before using, or allowed to stand until perfectly clear, when they may be carefully decanted. One Bunsen battery will be found sufficient for coating small articles.

In preparing articles to be coated with nickel, it is absolutely necessary that they should be thoroughly clean. It is even more important that cleanliness should be observed in nickel-plating than in gilding or silvering, and for this reason—the cyanide of potassium in the ordinary plating-bath would have a tendency to dissolve any trifling amount of greasy matter communicated by the hands, for instance, whereas the nickel solutions would not have that power. Extreme cleanliness, therefore, must be observed in preparing work for the nickel-bath. Again, it is important that all *interstices* should be well looked after, and every speck of dirt removed before the articles are placed in the bath. It is also advisable to put the articles in the solution immediately after they have been properly prepared, for if they were allowed to remain, even for a few moments, either in contact with the air, or to lie for a time in the rinsing-bath, they are apt to become coated with a film of oxide, which is quite sufficient to render the nickel liable to strip or blister when burnished or even polished.

The Chairman of the Plating Company, at the author's request, has kindly forwarded to him a specimen of nickel deposited at the Company's works; it is a thoroughly good reguline deposit, uniform in surface, and susceptible of a high polish. The thickness of the specimen shows that the Plating Company does its work conscientiously, and not merely to look but to wear well. Considering the hardness of this metal, goods coated with nickel of the thickness of the specimen referred to would possess almost everlasting durability in the hands of ordinarily careful persons. The great success which the Plating Company has attained is, no doubt, due to the excellent quality of its work, and the liberal amount of metal which each article receives before it is returned to the customer. The mistaken policy of competition which has induced many manufacturers to give a mere film of deposit upon their work—by which the goods assume a virtue which they do not possess—does not appear to have been adopted by this Company, for which it deserves all credit.

Tin.—Some of the salts of tin are soluble in liquid ammonia, caustic potassa, or caustic soda, and the metal may be deposited from either of these solutions; a little cyanide favors the rapidity of the deposit. Tin may also be deposited from an acid solution, the protochloride for instance, and a very beautiful effect is produced by bringing the anode and cathode within an inch of each other, in which case a fine mass of *crystals* of tin will start out from the negative pole, approach the positive pole, and gradually assume many beautiful and eccentric forms. The slightest motion causes the crystals to fall from the electrode.

Zinc.—Many persons have tried to deposit this metal from acid solutions—more especially from a solution of the sulphate—but for all practical purposes the processes have been a failure. The principle of depositing metals upon each other in an acid solution is bad, owing to the fact that the metal, when coming in contact with the acid solution, generally becomes acted upon without the aid of the battery.

In 1855 I patented a process for depositing zinc from an alkaline solution, which gave exceedingly beautiful results, and the metal deposited thereby was tough, reguline, and otherwise well suited to many practical purposes. As I believe the process is susceptible of many practical applications, it will be found fully described in the subjoined

SPECIFICATION.

My Invention consists, firstly, in forming a solution for the purpose of coating iron or steel with zinc by galvanic agency. To form the solution I proceed as follows:—I dissolve 200 ounces of commercial cyanide of potassium in twenty gallons of water (rain-water or distilled water being preferable) in a suitable vessel; I then pour into this solution 80 ounces by measure of strong liquid ammonia (of the specific gravity of ·880 I prefer). Having stirred these compounds together, I place several large porous cells, such as those used in Daniell's batteries, in this solution, and pour into each of the porous cells as much of a strong solution of a cyanide of potassium (say, about 16 ounces to the gallon) as will be equal to the height of the solution in the larger vessel; I then attach several pieces of metal, copper or iron by preference, to pieces of copper wire, which are then to be attached to the negative pole of a galvanic battery. These pieces of copper or iron are to be placed in the porous cells. I next attach a piece or several pieces of zinc to the positive pole of the battery, and I then immerse these pieces of zinc in the solution of cyanide of potassium and ammonia. For the above purpose I prefer using good milled zinc, the weight of which is to be ascertained before immersion; and I think it better to "pickle" the zinc slightly, previous to immersion in the cyanide solution, with dilute hydrochloric acid, after which process it should be well rinsed in clean water. The galvanic battery is now to be set in action, and allowed to continue in action on the above materials until the solution of cyanide of potassium and ammonia has taken up about sixty ounces of zinc, that is to say, about three ounces to the gallon of solution.

As soon as the pieces of zinc have been weighed to determine the amount dissolved into the cyanide solution, I dip them into dilute hydrochloric acid, and then rinse them, when they are placed aside for future operations, if necessary; the porous cells are then to be removed. I now dissolve 80 ounces of a carbonated alkali (I prefer the carbonate of potassa) in a portion of the above solution, and when dissolved I add it to the original solution, and stir the whole together for a few moments, after which I allow the solution to stand undisturbed until the sediment formed has subsided; I then transfer the clear solution to another vesse., when it is ready for use.

The above solution may be made in a more concentrated form, say, with half the quantity of water, and it may be diluted down to the required strength by adding more water when wanted to be worked. I prepare cast or wrought iron or steel to be coated with the above solution in the following manner, having first made a pickle composed of,—

Sulphuric acid	1 pound.
Hydrochloric acid	½ "
Water	2 gallons.

The articles to be coated are first plunged into the above pickle, and allowed to remain until the oxide of iron is easily removable with a brush, sand, and water. As soon as the articles are sufficiently pickled, they are to be rinsed in clean water, and are then to be cleaned with a hard brush, sand, and water; and any oxide which may not have been quite removed by the pickle may be scraped or otherwise removed, or the article be returned to the pickling bath until these parts yield to the brush and sand; or the iron or steel may be cleaned by the processes ordinarily used at the "galvanised iron works." When the articles to be coated are quite free from oxide, they are to be well rinsed in clean water, and immediately placed in the zincing bath, in connection with the negative pole of the battery.

As soon as the articles have received a slight coating they should be removed from the bath and examined, in order to ascertain if there are any parts remaining unclean, in which case those parts should be cleaned, and the whole article once more brushed all over as before and then returned to the bath, where it is to remain until sufficiently coated. It is as well, however, to move the article about in the solution occasionally, in order to insure an uniform deposit. As soon as the articles are sufficiently coated they are to be removed from the bath and rinsed in clean water (hot water being preferable), and they may then be placed in saw-dust to dry them. The articles may be rendered bright either by means of the scratch-brush, or by gently scouring with silver sand, water, and a soft brush. When the above solution has been in use some time it will be necessary to add occasionally a little cyanide of potassium and liquid ammonia, so as to keep the solution at as near as possible the original strength; and if the solution, from being worked with too small a surface of positive electrode, or from other causes has become deprived of a portion of its zinc, I place in the solution (by suspension or otherwise) several porous cells, which I fill with strong solution of cyanide of potassium, and into which I put pieces of copper or iron as before, in connection with the negative pole of the battery, and the zinc electrodes I attach to the positive pole of the battery, by which means I am enabled to keep up the strength of the solution. The above solution is to be worked with zinc electrodes (milled zinc being preferable), and it will be necessary in coating flat surfaces especially to place a piece of zinc on each side of the article to be coated; for instance, if sheets of iron are to be coated, they are to be placed in the solution alternately, that is to say, sheet zinc, sheet iron, sheet zinc, and so on, (the sheets of iron and zinc exposing about the same area of surface,) otherwise the surface opposite the zinc electrode will receive the greatest amount of deposit. I prefer using a battery which yields a considerable quantity of electricity, and the action of which can be maintained for a considerable time without losing its power, by which means I not only secure a good deposit, but uniform results. The battery which I prefer is that known as Bunsen's battery, or a battery composed of carbon and zinc elements. Two or more 4-gallon cells of this battery may be used when large articles are to be coated, or when a considerable quantity of work is to be done in the bath at one time. When cast or wrought iron or steel has become much rusted, it may be cleaned with strong hydrochloric acid, or with a strong pickle composed of hydrochloric acid and water, but it must not be allowed to remain too long in this pickle, or the iron or steel will be acted upon.

Articles of cutlery may be coated by the above process to preserve them from oxidation or rust in damp climates or during sea voyages, &c., and as they will only need a slight coating for this purpose, they will not require to remain long in the bath. In pickling bright steel articles, I should not recommend the use of any hydrochloric acid.

Electro-deposition of Alloys of Metals.—Besides the metals already referred to, I have succeeded in depositing an alloy of copper and nickel, forming a very good quality of German silver, by dissolving German silver in nitric acid, precipitating with an alkali, and re-dissolving with cyanide of potassium.

Silver and gold—forming what jewellers term "green gold"—may also be deposited by adding to a solution of gold a small quantity of solution of silver, but the solution must be worked hot, and with weak battery power. Copper and gold may also be deposited together in the same way. However, the only alloy which seems to have much practical value in it is that of brass, and an extensive manufacture is now being carried on in this art both in England and on the continent.

I trust that the reader will find in the foregoing pages sufficient practical matter to enable him to work the various processes described with facility and certainty of success. I have endeavoured to divest the details of any unnecessary technicality, and to give each process with as much conciseness and simplicity as possible, in order that the student might at once arrive at the readiest mode of setting to work. Those processes which I have dwelt fully upon, are those which I have found most practicable and economical, and consequently more likely to succeed in the hands of the uninitiated.

I propose giving, in the form of an appendix, a few practical memoranda, which I hope may prove equally serviceable to the beginner and the practical electro-metallurgist.

APPENDIX.

1.—In dissolving gold in *aqua regia* (two parts hydrochloric acid and one part nitric) care must be taken that the acids are pure, and that the gold be perfectly *fine*, or at least not inferior to sovereign gold.

2.—If the operator requires to dissolve gold of inferior quality, for the purpose of making his gold solution, he should first treat the gold in the following manner:—To one ounce of alloyed gold of the same quality as that which "colored" gold chains are made of, add two ounces of silver. These are now to be placed in a crucible and melted in a furnace, a little borax being added as a flux. As soon as the alloy is thoroughly melted, it should be poured into a deep vessel of cold water (kept well stirred in a circular direction all the time), and thus it will become "granulated," as it is termed. The granulated metal is now to be removed, and placed in a Florence flask, and to be treated with one part nitric acid and two parts water. This is allowed to digest for an hour or so; applying gentle heat when the chemical action diminishes in vigour. The nitric acid will remove all the copper and silver from the gold, which latter will remain at the bottom of the flask in the form of a dark brown irregular mass. The acid, which will have acquired a green colour, may now be poured into a separate vessel. It will be well to add a little fresh acid to the gold, applying heat as before, in order to be sure that all the copper and silver have been removed. If the acid does not produce chemical action (which may be seen by the absence of red fumes in the body of the flask), the operation is complete. The gold is now to be washed well with hot water, and the washings are to be added to the first solution which was poured from the flask. The gold in its present state may be dissolved with nitro-hydrochloric acid, and thus converted into chloride; or it may be dried, mixed with a little dry potash, and fused in a crucible. When melted, the gold may be granulated, or poured into an ingot.

The solution of nitrate of silver and nitrate of copper formed above, may be thus treated, in order to collect the former:—Put into the vessel containing the green solution a piece of stout sheet copper. In a few moments the silver will begin to deposit itself upon the copper, and by continuing the process for some time—adding a gentle heat, the whole of the silver will eventually become precipitated in the form of minute crystals. In order to ascertain whether all the silver is thrown down, pour a little of the green liquor into a wine glass, and drop in a little hydrochloric acid, which, if any silver be still present in the solution, will form a white precipitate. If, on the contrary, no precipitation takes place, the green solution may be poured off and thrown away. The silver is to be washed several times, to free it from the copper, and when the last washings pass off clear, the silver may be dried and melted, with a little potash, in a crucible; or it may be dissolved in nitric acid and used for making a plating solution.

The copper may be thrown down from the above solution, when the silver is extracted, by immersing in the solution a few pieces of iron, but it is never worth while to do this except for experimental purposes. The solution, however, may be used with the sulphate of copper batteries.

3. Sometimes, when gilding the insides of mugs, tankards, &c., which are richly chased or embossed, it will be found that the hollow parts do not receive the deposit at all, or very partially. When this is the case, the article must be rinsed and well scratch-brushed, and a little more cyanide added to the solution. The anode should be slightly kept in motion and the battery power increased until the hollow surfaces are coated. Frequent scratch-brushing aids the deposit to a great extent, by imparting a slight film of brass to the surface.

4. Silver filagree brooches and articles which have been annealed and cannot be scratched bright, owing to their peculiarity of construction, are frequently troublesome to gild, for the rough surfaces caused by the fire, in the process of annealing, are indifferent conductors

of the current. It will therefore be advisable to scratch-brush the articles as far as practicable, and to add a little more cyanide of potassium to the solution in which this class of work is to be gilt. The article must be constantly moved about, in solution, until coated all over. The battery-power should be brisk.

5. When articles gild a "foxy" colour, as it is termed, this is either owing to the presence of too much cyanide, excess of battery power, or exposure of too large a surface of anode. When this defect shows itself, raise the anode a little and keep the article in motion while in the bath, or remove the anode altogether and move the work about in the solution for a few seconds. This will generally remedy the defect. The power of the current, however, should be diminished, or the anode will become wasted.

6. When a gold solution has been worked for a long time, it becomes contaminated with organic matter, and the deposit is of an inferior colour in consequence. In this case, I have observed that the solution may be restored to good working condition by evaporating it to dryness, and then adding distilled water to re-dissolve it. A little cyanide should then be added, and the solution filtered for use. The heat required to evaporate a solution to dryness does not, as many people suppose, impair the solution, or decompose it; it merely appears to destroy the organic matter and to prevent its influence in the working of the solution.

7. It is sometimes found impossible to make a gold solution work well which has been in use for some years, even evaporation to dryness failing to restore it. It is therefore better and more economical to abandon it altogether and make another. The gold from old solutions may be recovered by means of the battery, or by precipitating the gold with acid. If the former plan is adopted, a piece of copper should be attached to the negative pole of the battery, and another piece (as an anode) be attached to the positive pole. When the battery has been in action for some time, the gold—or at all events the greater part of it—will be deposited upon the negative pole, from which it may be removed by mechanical means, or by dissolving it off with nitro-hydrochloric acid. If it is preferred to throw down the gold from the solution with acid, the solution must be placed in a large vessel *in the open air*, as the fumes which will arise are highly deleterious if breathed, and sulphuric acid poured in carefully until no further effervescence takes place. The precipitate formed should be allowed to subside, when the clear liquor may be poured off and thrown away. The precipitate may be washed with hot water; after which it may be dried, mixed with a little potash, and fused in a crucible until the gold is gathered into a button. The operator will seldom find that he can recover nearly the amount of gold that he put into the solution; owing to the irregularities of working, the solution becomes deprived of a considerable proportion of gold, and I have frequently found that old solutions will yield scarcely any metal worth speaking of.

8. In gilding, if a copper and a silver article be immersed in the solution together, the copper article will receive the deposit first, and the silver article will be troublesome to gild sometimes under such circumstances; and in trying to force the gold upon the silver, probably the copper article will receive the deposit so quickly that it will be liable to strip off when scratch-

brushed. The silver article, therefore, should be placed in the solution first, and when it is coated, the copper one may be suspended by its side.

9. Each metal to be gilt plated or brassed, should have a solution for itself, otherwise the bath in which several different metals have been coated, will become impaired, unless, however, each metal has first been coated by itself to some extent.

10. When it is found that the operator cannot, from some cause or other, produce a good colour when gilding, it is useful to have at command the means of improving the colour without the trouble and annoyance of persevering with an indifferent gold solution. Some gilders employ the following mixture to give an artificial colour to gilt work; and provided the work is strongly coated, it may be used with advantage:—

Alum	3 ounces.
Nitrate of potassa (saltpetre)	6 ,,
Sulphate of zinc	3 ,,
Common salt	3 ,,

Mix the above materials into the form of a thick paste, dip the articles in it, or brush them over with the compound, and place them on a piece of sheet iron. The iron is to be heated over a clear charcoal or coke fire, until the articles appear nearly black, when they are to be plunged into cold water. A very useful formula, and one which may be used with less care than the above—especially for small work, is the following:—

	OZS.	DWTS.	GRS.
Sulphate of copper	0	2	0
French verdigris	0	4	12
Chloride of ammonium (Sal ammoniac) .	0	4	0
Nitrate of potassa	0	4	0
Acetic acid . . . . (about)	1	0	0

Reduce the sulphate of copper, sal-ammoniac and nitrate of potassa to a powder, in a mortar; then add the verdigris, and pour in, little by little, the acetic acid, stirring well all the time; the whole will assume a bluish-green mass. The article to be coloured is to be dipped into this mixture, and, being placed on a piece of sheet copper, heat is to be applied until it assumes a black colour. It is allowed to cool, and is then placed in a tolerably strong sulphuric acid pickle, which will dissolve the colouring salts, and the article will assume a rich fine gold colour. It is sometimes advantageous to scratch-brush the article before submitting it to the above process, and it will then come out of the pickle perfectly bright. The article, when removed from the pickle, is to be well rinsed in warm water to which a little potash has been added. A soft brush and soap and warm water, skilfully applied, will tend much to improve the article—especially if the work is either chased or embossed.

11. Moving the articles about in the bath, will at all times enable the operator to vary the colour of the deposit from pale straw-colour to a very dark red. The temperature of the solution likewise influences the colour of the deposit, the colour being lightest when the solution is cold, and gradually becoming darker as the temperature increases. Variations in the surface of anode exposed while the articles are in solution, will also alter the colour of the deposit. The amount of cyanide in the bath and the strength of battery-power, influence the deposit in the same way.

12. If there be not sufficient cyanide in the gold solution, the anode will not become freely dissolved; consequently, as has been shown, the solution will soon become exhausted of its gold, and the articles gild of an inferior colour. Adding more cyanide, under such circumstances, will not remedy the defect, but a little concentrated solution of gold should also be added at the same time.

13. In gilding watch-movements, the greatest care must be observed with regard to cleanliness. The work is first to be placed in a weak solution of caustic potassa for a few minutes, and then rinsed in cold water. The movements are now to be dipped in pickling acid (nitrous acid) for *an instant*, and then plunged *immediately* into cold water. After being finally rinsed in hot water, they may be placed in the gilding-bath and allowed to remain until they have received the required coating. A few seconds will generally be sufficient, as this class of work does not require to be very strongly gilt. When gilt, the movements are to be rinsed in warm water, and scratch-brushed; they may then be returned to the bath, for an instant, to give them a good colour. Lastly, rinse in hot water, and place the movements in clean box sawdust. An economical mode of gilding watch-movements, is to employ a copper anode—working from the solution—which must be re-supplied with gold from time to time as the solution becomes exhausted.

14. When an article is immersed in the silver solution, if it assumes a dark colour, either the solution is too rich in cyanide, the battery-power is excessive, or too large a surface of anode is employed. Any one, or all of these conditions combined, will cause this defect. The operator should at once remove the article (unless it be made of Britannia-metal, pewter, or lead), and have it cleaned again by the usual process. It may

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then be returned to the bath, and a much smaller surface of anode exposed. This will at once alter the colour of the deposit, and the anode can be lowered a little from time to time, to increase the speed of the operation. Should the article, however, still receive a dark-coloured deposit, either the solution must be weakened with water, or the battery-power reduced. But the solution should not be altered until the other remedies have been tried.

15. When it is desired to give to a plated article, or a portion of the same, that appearance which is technically termed "oxidation," any of the following processes may be employed with success. Sometimes very pleasing effects may be produced upon silver work by the "oxidising" processes.

1. Dissolve 1 dwt. of platinum in *aqua regia*. Evaporate the acid, and when the resulting red mass is quite cold, dissolve in a little sulphuric ether or alcohol. Or the chloride of platinum may be dissolved in cold water, or used, in its acid state, before evaporation. Apply with a camel's hair pencil to those parts which are required to be "oxidised," and as soon as the spirit or ether has evaporated, the pellicle of platinum remaining will give the appearance required.

2.	Sulphate of copper	2 dwts.
	Nitrate of potassa	1 ,,
	Muriate of ammonia	2 ,,

Dissolve in a little acetic acid. Apply with a camel's hair pencil. The article should be warmed before using this mixture.

3. Hydrosulphate of ammonia, strong or diluted, will give either a dark or light tint of oxidation.

4. The fumes of sulphur will give to silver an extremely beautiful blue steel-like surface. The operation should be conducted in a closed box, all parts of the article not to be coloured being protected with a suitable cement or wax.

5. Nitric acid alone will produce an oxidised surface upon silver.

16. Certain parts of an ornamental silver article may have a very pleasing effect produced upon them by oxidising some parts, gilding others, and then depositing a slight coating of copper upon small portions of the article, which may be done in the following manner :—Dissolve a little sulphate of copper, and add a few drops of sulphuric acid; apply this solution to the part to be coated, with a camel hair brush, now touch the moistened part with a piece of steel wire, and it will instantly become coated with copper. Any design can be worked in copper by this means; but it is not necessary to state, that the amount of copper deposited is very trifling, consequently the article should not be subjected to much wear.

17. When a silver solution works badly, and it appears impossible to restore it by the ordinary means, the operator may precipitate the silver with sulphuric acid in the manner described for gold (page 96). The precipitate is to be well washed, and may then be re-dissolved with cyanide of potassium. Water is then to be added to make the required amount of solution, and in all probability it will work as well as ever. The solution should be filtered before using, which may be conveniently done before adding the bulk of water.

18. If, when silver anodes are used, the solution contains a great excess of free cyanide, the anodes will

dissolve away irregularly, and sometimes numerous small particles of silver drop off the anode; these particles, if allowed to fall on the work to be plated, will render it rough. It is therefore, under such circumstances, advisable to place the anode in a canvas bag, or a bag made of Holland linen, by which means the small granules of silver will be retained, and may be collected from time to time, and melted or dissolved to make nitrate of silver.

19. In "stripping" articles, by the process given at page 56, the operator must take care that the fumes arising from the process are not allowed to enter the apartment in which he is operating, as they are exceedingly offensive and injurious. The process may be carried on upon a sand-bath, with a flue above, or upon the hob of an ordinary stove.

20. Sometimes the silver thrown down from stripping solutions, when melted and cast into an ingot, will not, if submitted to the "flatting-mill" to be rolled out, roll well, but will crack under the operation. This defect is probably owing to the presence of a small quantity of zinc. It is better, in such a case, to remelt the silver with a small portion of copper, or to throw in some nitrate of potassa when the silver is in a state of fusion.

21. When silver or electro-plated articles have become much tarnished by exposure to the atmosphere, the surfaces may be cleaned by brushing over them a strong solution of cyanide of potassium; or strong liquid ammonia will answer the same purpose. Jewellers' rouge, in the form of a paste, applied with a stiff brush, will render the surface of chased work clean, but the bright surfaces should be polished with the

palm of the hand, and moist rouge, which is rubbed on until it becomes quite dry, and the hand appears black from the silver which has worked off the article by friction. When the articles are very dull, a little rottenstone may be applied before the rouging process.

22. Gold may be stripped from articles which have been gilt, by placing them in strong nitric acid, to which a little dry common salt has been added. When the gold is removed, the articles should be at once rinsed and cleaned in the ordinary way. When the nitric acid stripping solution has been worked a good deal it removes the gold but tardily; it should then be cast aside, and the gold collected by evaporating the solution to dryness, and fusing the residuum with a little potassa or soda. When the gold is fused into a button, a little nitre may be added occasionally, in order to refine it thoroughly.

23. As deposition takes place more rapidly upon those surfaces which are nearest the anode, it will be necessary, in order to coat the goods as uniformly as possible, to move them occasionally, and to present a different surface to the anode. By doing this frequently, a tolerably uniform deposit may be secured. Or the anode may be shifted to effect the same result. Presuming that electro-deposition takes place principally where the article is in "electrical sight" with the anode, it is well to surround the work with surfaces of metal to be dissolved, which will save the necessity of frequently moving the articles in solution.

The insides of cream-ewers, sugar-bowls, teapots, &c., since they cannot be placed in such a position that the insides will be exactly opposite the anode, may first receive a deposit inside by filling the vessel with silver solution, and proceeding in the same way as in gilding the inside of a vessel. Or this may be left until the article is well coated outside. Generally speaking, it is better to let the solution be slightly moved occasionally, in order to expose fresh surfaces of the solution to the work being plated.

24. Stout copper wires conduct the current better than fine wires; consequently, the wire employed in connecting the work to be plated and the anodes with the battery should be always sufficiently stout to carry the current freely. For a single cell, wire about one-sixteenth of an inch in thickness will be sufficient, but where a series of cells are employed, in electro-brassing for instance, the wire should be much thicker,—say at least one-eighth of an inch thick. If too thin a wire is used, when the battery is in circuit,—that is, when it is connected with the anode and goods to be coated,—the wire will sometimes become quite hot, owing to its being unable to convey the amount of current generated.

25. It is always advisable to commence the process of electro-deposition with moderate battery power, which may be augmented after a little while, except in those cases referred to in a former part of this work. If too strong a current is employed, the articles will, in all probability, "strip" in the process of scratch-brushing or burnishing. Again, when the battery power is very strong, the solution becomes decomposed. As a rule, no effervescence or frothing should be allowed to take place in a plating bath.

26. Electro-deposition will proceed much quicker when the temperature of the atmosphere or solution is high; therefore, the operator should observe that the surface of anode be not too great at first, or the battery power excessive, or the deposit will be faulty. Whenever a warm solution is employed, deposition should be allowed to commence slowly at first, gradually lowering the anode as the coat thickens.

27. Deposition from silver or gold solutions takes place more actively upon brass, German silver, or copper, than upon silver or gold; therefore the operation must be carried on slowly at first. When a copper or brass article becomes covered with silver, deposition does not proceed quite so rapidly as at first, when the inferior metal was exposed in the solution; the manipulator may therefore accelerate the speed of the operation as before recommended. The same operation applies to gilding. Gold is more easily deposited upon brass or copper than upon gold; therefore, after the first layer has been deposited, the operation may be carried on more vigorously.

28. The apartment in which electro-deposition is carried on should be kept as dry as possible, and the temperature at about 60° F. In warm weather, when the apartment assumes a higher temperature, the strength of battery power, &c., should be regulated accordingly, otherwise deposition will take place too rapidly.

29. Batteries employed for this purpose, should be made to work as uniformly as possible. When a battery works slowly, it is better to take on an extra cell of about equal power, than to make frequent additions of acid to the battery, which is apt to cause it to act irregularly.

30. The zinc employed in a battery, when not excited by salt and water, should be "amalgamated." This is accomplished by placing some mercury in a dish with a little hydrochloric acid. A piece of flannel or baize, tied to the end of a stick, and dipped into the acid and mercury, is to be rubbed all over the cylinder or plate of zinc, until it assumes the characteristic brightness of mercury. When a cylinder of zinc is to be amalgamated, I have found that putting mercury into a coarse flannel bag, dipped now and then into hydrochloric acid, and applying it first to the outside of the cylinder, renders the process of amalgamating this surface very simple and effective, when only a small quantity of mercury is at hand. This is a very economical method, as with care little or no waste of mercury occurs. When the amalgamated plate or cylinder has been in work some time, the operator should observe if "local action" is taking place upon any part of the metal. When this is the case, it is accompanied by a violent effervescence within the cell. The cylinder, &c., should be at once removed from the cell, and those parts which have been most violently attacked by the acid solution, must be re-amalgamated. Where local action takes place, the part is generally of a dull and dark grey colour.

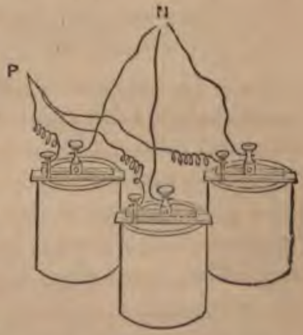
31. The copper cylinders and plates used in batteries, should be occasionally cleaned with dipping nitrous acid, and then rinsed in cold water, or they may be scoured with sand and a hard brush.

32. When the copper conducting wires become corroded by being splashed with solution, &c., they should be cleaned with a piece of emery cloth. I have found it advantageous to coat these wires with silver—this metal being less liable to corrosion than copper.

33. In using binding screws for connecting the wires of a battery with the anode and goods to be coated, the operator must take care that the connection between the point of the binding screw and the wire is clean, otherwise the current will be conveyed partially or not at all. It is well to slightly file the point of the screw before using it, or to roughen it with a piece of coarse emery cloth, which will enable it to *grip* the wire better. The hole through which the wire is passed, may be kept clean with a small round file. When binding screws become very much corroded, they may be pickled in sulphuric acid and water, for a few hours, and then cleaned with a hard brush and sand; or they may be dipped in nitrous acid.

34. Strips of sheet copper will be found very convenient substitutes for copper conducting wires. The strips may be cut from a sheet about $\frac{1}{32}$ of an inch in thickness.

35. In working a battery for electro-deposition, the operator must secure a considerable *quantity* of electricity of sufficient *intensity* to give the necessary activity to that quantity. I prefer, when arranging two or more cells of a battery, to deposit silver, attaching the wires connected with the zinc elements to the metal rod on which the articles to be coated are suspended, and the wires proceeding from the copper elements I attach to the anodes. By this arrangement, the quantity is multiplied by the number of cells employed; whereas,



if the cells are alternated—that is, the zinc of the one cell to the copper of the next, and so on—the intensity is multiplied and the arrangement only gives the quantity of one cell.

36. When it is desirable to deposit the metal in a *hard* state, it may be advantageous to alternate the cells, so as to increase the *intensity* of the current, as this quality of current seems to affect the nature of the deposit. A good tough reguline deposit appears to be dependent upon the current being feeble in intensity, but considerable in quantity.

37. In depositing brass, however, the reverse seems to be the case, for here greater intensity is absolutely necessary, or the copper alone will be deposited. I have generally found that at least two cells of the zinc and carbon (an intense) battery, alternately arranged, have been necessary to obtain a deposit of good colour. Again, if the battery be too powerful, the zinc only will be deposited. The exact *mean* appears to be absolutely necessary to obtain good results in electro-brassing.

38. When the anodes are only partially immersed in the solution, and have been worked for some time, the metal will dissolve off rapidly at the surface which is just out of the solution, and probably the anode may be divided, and fall into the solution. It is advisable, therefore, occasionally to shift the position of the anode in order to prevent this local action upon it. It is a good plan to suspend the anodes employed in gilding by stout platinum wires, so that the whole of the anode may be immersed when necessary, without the solution being injured.

39. In preparing solutions, more especially gold and silver solutions, distilled water should be employed;

but, when large quantities of solution are required, this may be inconvenient; therefore, rain-water, if it can be obtained, may be substituted; or water which has been boiled, losing some of its impurities, may be used in preference to common water. Pump-water is very objectionable. If rain-water is employed, it should be filtered before using; and it is better to collect it as it falls *direct* from the atmosphere, rather than use that which falls off the roof of a house, &c.

40. Electro-deposition of gold and silver may be carried on by the "single cell" arrangement; but, although very good results may be obtained by it, it is of very little commercial importance. The operations of gilding and plating, when conducted by the separate battery, are so simple that even the "single cell" process, simple as it is, will scarcely be employed, except for experiment.

41. In gilding or plating by the "single cell" process, however, a jar is fitted with a cylinder of zinc inside, which is excited either with sulphuric acid and water, or salt and water. A porous cell is placed in the centre, which is filled with either gold or silver solution. A strong copper wire is soldered to the zinc, to which the article to be gilt or plated is suspended, by means of a thinner wire, and the moment the article is immersed deposition takes place.

42. It is advisable to *anneal* the anodes before using them. This may readily be done by making them red hot over a clear fire (a charcoal fire being preferable), and then allowing them to cool. The anodes of gold, silver, copper, and brass may be plunged into dilute sulphuric acid after they have been annealed, by which their surfaces will be rendered quite clean and free from the "fire mark." Brass and copper anodes may be dipped in nitrous acid for a moment, and then plunged into cold water.

43. Cyanide of potassium may be prepared, for electro-chemical purposes, by the following process:— A quantity of commercial ferrocyanide of potassium is to be reduced to a powder; it is then to be roasted on an iron slab, or piece of sheet-iron with its edges turned up to prevent the material falling off. The heat is to be continued until the substance is quite free from water of crystallisation, which will become evident by its losing its transparency. If the heat be applied too suddenly, the ferrocyanide is apt to *decrepitate*, and much of it may be lost. Care must also be taken not to apply too much heat, or it will become fused to the iron slab. When the ferrocyanide is dried, it is to be mixed intimately with *dry* carbonate of potassa, in the following proportions:—

Dried ferrocyanide	16 ounces.
,, carbonate of potassa	8 ,,

Both materials being well mixed, they are to be placed in an iron crucible or ladle, which should be previously made hot, and the whole subjected to a strong heat in a coke fire; the heat may be increased as fusion progresses. When the substances have fused into a liquid, they are to remain in this state for about a quarter of an hour; the crucible is then to be removed from the furnace, and its contents allowed to settle for a few moments; the clear liquid may then be carefully poured out, either into a shallow iron mould or upon an iron slab or dry flag-stone. The sediment remaining at the bottom of the crucible should be shaken out while hot, or it will be troublesome to remove it. It is a good plan, while the cyanide is fusing, to dip an iron rod into the mass occasionally, and then to examine the portion thus removed, which will be brown at first, and subsequently white when the process has been carried far enough.

44. Sometimes electro platers have employed ferrocyanide of potassium (yellow prussiate of potassa) instead of the cyanide in forming silver solutions, but this substance has not been found to answer well, since it has not the power of dissolving the anode, therefore the solution soon becomes exhausted of its silver. Again, it requires so large a quantity of the ferrocyanide to keep the solution in action, that eventually it crystallises upon the inner surface of the bath.

45. Hyposulphite of soda has also been employed as a substitute for the cyanide of potassium; but since the solution which is formed with it is very readily acted upon by light, it is never likely to become much employed; besides, the solutions made with cyanide of potassium are found, for all practicable purposes, infinitely superior to those made with this or any other substitute.

46. Mr. George Knight, the eminent philosophical instrument maker of Foster Lane, Cheapside, has lately drawn my attention to a very ingenious and portable battery, consisting of two zinc plates and a plate of platinised carbon, or graphite, united by suitable binding screws, and placed in a glass cell. This arrangement, I believe, is due to Mr. C. V. Walker. The battery is excited with sulphuric acid and water, and is capable of yielding a powerful current without any unnecessary waste of material. This battery is certainly one of the most simple and effective which has been introduced for some years, and in the hands of the student it cannot fail to give many pleasing results with but little trouble and expense.

There are many other processes for the electro-deposition of metals upon each other besides those enumerated in this work; but the author,—being desirous merely to enter into the consideration of those processes which are of a practical nature, and which may be pursued by the student for commercial purposes,—has confined himself, as far as possible, to detailing those processes which are most likely to succeed with the beginner. At the same time it is hoped that many who are now practising the art of electro-metallurgy, either as gilders, platers, or bronzers, may glean from these pages some useful hints, and which the author trusts will repay the reader for the time devoted to the perusal of this little work.

TABLE OF WEIGHTS AND MEASURES.

APOTHECARIES' WEIGHT.

1 Pound	*equals*	12 ounces.
1 Ounce	,,	8 drachms (480 grains*).
1 Drachm	,,	3 scruples.
1 Scruple	,,	20 grains.

TROY WEIGHT.

1 Pound	*equals*	12 ounces.
1 Ounce	,,	20 pennyweights (dwts.) (480 grains*).
1 Pennyweight	,,	24 grains.

IMPERIAL MEASURE.

1 Gallon	*equals*	8 pints.
1 Pint	,,	20 ounces.
1 Ounce	,,	8 drachms
1 Drachm	,,	60 minims.

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* An ounce Avoirdupois is only 437·5 grains.

47. Silver articles which are required to be left a dead white should be thus treated:—The article is first to be heated to "cherry redness" (*i.e.*, a dull red heat), and is then to be allowed to cool. When quite cold it is to be placed in a pickle of *very* dilute sulphuric acid (about 5 parts acid in 100 parts water). The article should remain in this pickle for an hour or two; and if not sufficiently uniform in surface, it should be rinsed in hot water, dried spontaneously, and again heated as before—the operation of pickling being repeated. As the object in this process is to remove the copper with which the silver is alloyed, the repeated pickling will not produce any injurious result, but will merely remove the copper from the *surface* of the article, leaving fine silver alone upon the surface. A solution of alum in water may be substituted for dilute sulphuric acid, if preferred. In either case the solution should not be used more than once or twice, and then be thrown away.

After the article has been *whitened* as above, it must be removed from the pickle, and be well rinsed in hot water, which for this purpose must be absolutely clean, and then placed in warm box-sawdust. It is well to keep perfectly clean box-dust for articles which have to be whitened, as the slightest stain in some cases would be fatal to the object sought. In whitening silver watch-dials, great care must be taken not to warp the dial in the process of annealing. The dial should be placed on a perfectly flat piece of charcoal,* face upward, and a gentle blast with the blowpipe carefully applied, and as far as practicable the flame should play *all over* the surface of the dial without absolutely touching it, by which means the dial will soon become sufficiently heated, without becoming warped or in any way injured. Silver dials may also be annealed by placing them upon a flat sheet of copper, which is then brought in contact with a clear fire until red-hot.

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* A flat surface may be given to charcoal by rubbing it upon a flag stone.

48. Brass time-piece dials may be whitened, *i.e.*, silvered, by rubbing a mixture of chloride of silver (silver precipitated from the nitrate with common salt or hydrochloric acid) and common salt. The mixture should be worked up into a thinnish paste, and be applied with a soft cork or piece of washleather. The dial is then to be rinsed and placed in box-dust.

49. The sediment which accumulates in the scratch-brush box should be carefully preserved and dried, and this, with other waste of a similar description, collected and fused with dry carbonate of potash; and as the resulting "button" will be an alloy of gold, silver, copper, &c., it will be necessary, in order to refine it, to proceed as follows:—Remelt the alloy, and "granulate" as before described; then place the grains in dilute nitric acid (2 parts acid to 1 part water), which will dissolve all but the gold, the latter remaining as a brown powder at the bottom of the vessel in which the operation is conducted. The solution formed should next be poured off into a jar or basin, and a piece of copper immersed, which will at once throw down all the silver. The silver and gold thus obtained will require to be well washed with hot water, and finally dried and fused.

50. Gold articles may be "coloured," as it is termed, by immersing them in the mixture described at page 97, line 17. The mixture should be placed in a common pipkin, and allowed to fuse, the articles being removed occasionally to ascertain if they be of good colour. After the articles have been removed from the pipkin, they should be allowed to cool, and then immersed in dilute sulphuric or acetic acid, which will remove the flux. When this is done, the articles may be rinsed in a weak solution of potash or soda, and finally brushed with hot soap-and-water; they must then be rinsed in hot water, and placed in clean warm box-sawdust. A badger-hair brush is the best to remove all traces of sawdust from articles which have been dried in it.

51. In gilding cast brass articles, which are required to be left dead in the hollow and chased surfaces, the best plan is first to wash the article in a solution of caustic soda (a solution of soapmaker's "soda ash" will do) or potash, then, after well rinsing, dip the article *for an instant* in fuming nitric acid, and after it has become thoroughly acted upon all over plunge it *instantly* in cold water: the article should then be well rinsed in hot water, and is then ready for the gilding bath. Articles of this description seldom require to be strongly gilt, the *colour* being the principal object. The *bright* surfaces may require to be burnished.

52. Electro-gilders and platers will do well to keep several burnishing tools on hand for small things which may be needed in a hurry, or which would not be within the ordinary province of a professional burnisher to accomplish. As mere friction is required, the operator may easily acquire the proper knack of using the tools. A small steel burnisher, about twice the size of a ladies' "stiletto" or eyelet-hole piercer, is a convenient tool for edges of brooch mounts, &c.

53. As it may be necessary that the electro-plater should be able to solder an article at a moment's notice rather than send it out to be done, he may derive advantage from the following hints:—The operator is to be provided with an ordinary "soldering iron" (which is made of copper, by the way!), and the face must be filed smooth with a keen file; after which it should be placed in a fire until hot, but not *red* hot. The soldering iron should then be "tinned," as it is termed; that is, rubbed on a piece of sheet tin with a little rosin and soft solder. As the face of the tool will have become slightly oxidised after removal from the fire, it will be necessary to pass the file over it again in order to clean the surface to be tinned. The moment this is done, plunge it *at once* into the rosin and solder, and by gently working the soldering iron over the surface of sheet tin, it will become coated with solder and fit for use. The soldering iron should never be allowed to be heated to redness, otherwise the solder becomes "burned," as it is termed, and, uniting with the copper, forms a hard alloy which the file will scarcely touch unless the tool is very hot. In soldering an article, the first thing to do is to clean the part to be soldered, which is generally done by scraping the surface with a sharp instrument, such as the point of a penknife, or, still better, a three-square scraper made out of an ordinary three-square file, and great care is necessary to ensure all parts which are to receive the solder being perfectly clean. The operator should provide himself with a solution of chloride of zinc, which is made by dissolving a few pieces of zinc (say half an ounce) in an ounce of hydrochloric acid; this solution may be kept in a widemouthed bottle ready for use. The solution of chloride of zinc is applied to the parts to be soldered with a camel-hair brush or the feather of a quill. As soon as this is done, and the parts to be soldered are brought together, the soldering iron should be again heated until it is hot enough to melt the solder freely. It should not only do this, but also take up a *globule* of the melted solder and hold it in suspension until borne by the operator to the part to be soldered. The instant the soldering iron touches the surface to which the chloride of zinc has been applied, the solder will "run" and attach itself readily. It will be necessary to hold a strip of solder in the hand, in order to apply more as required. Rosin may sometimes be employed instead of the chloride of zinc, but as a rule the latter will be found preferable. In connecting copper wire with zinc plates, the solution of chloride of zinc may advantageously contain an excess of acid; in fact, hydrochloric acid alone may be employed in the same way as the chloride of zinc. Small articles may be united with soft solder by the aid of the blowpipe. In this case the solder should be hammered flat, and, after being scraped clean, cut into small pellets; that is, first cutting the solder into strips and then cross-cutting into small squares. These pellets are to be placed upon the article to be soldered (after the parts have been scraped as before, and the chloride of zinc applied), and a jet of flame gently blown upon the article with the blowpipe will readily unite the parts.

54. All goods which are to be plated or gilt should be placed in the bath as soon as possible after being cleaned or scratch-brushed and rinsed: if they are allowed to remain long in water, or exposed to the air, a film of oxide is formed upon the surface of the metals, and which, however slight, has a tendency to prevent the gold or silver adhering firmly to the metal to be coated. It is not a good plan to prepare too many articles at one time for the bath, allowing them to remain in water until a quantity is ready: it is better to get them into the bath as quickly as possible, a few at a time, of course taking care that the surface of anode exposed and the battery power are regulated according to the *surface* of goods immersed in the bath at one time. When the number of things in a bath is increased, the anode must be lowered and the battery power rendered more vigorous. As we have said before, silver and gold do not receive the deposit of these metals so freely as copper, brass, German silver, &c.; therefore, when these metals have become coated to a certain extent with the superior metals, the battery power may be judiciously augmented and the surface of anode increased.

55. A very useful solution of silver or gold for plating or gilding without the aid of a battery may be made as follows:—

Take, say, 1 ounce of nitrate of silver dissolved in 1 quart of distilled or rain water. When thoroughly dissolved, throw in a few crystals of hyposulphite of soda, which will at first form a brown precipitate, but which eventually becomes redissolved if sufficient hyposulphite has been employed. A slight excess of this salt must, however, be added. The solution thus formed may be used for coating small articles of steel, brass, or German silver, by simply dipping a sponge in the solution and rubbing it over the surface of the article to be coated. I have succeeded in coating steel very satisfactorily by this means, and have found the silver so firmly attached to the steel (when the solution has been carefully made) that it has been removed with considerable difficulty. A solution of gold may be made in the same way, and applied as described. A concentrated solution of either gold or silver thus made may be used for coating parts of articles which have stripped or blistered, by applying it with a camel-hair pencil to the part, and touching the spot at the same time with a thin clean strip of zinc.

56. To the practical electro-plater, and even the amateur, it may be useful to become acquainted with the art of "hard soldering," as it is termed; and as there is frequently, especially in small provincial towns, a difficulty in getting even a small job executed with dispatch, we will give the reader a few hints upon the manipulation of this process.

"Hard soldering" consists in uniting any two metals, or parts of the same metal, by means of an alloy composed of two parts of silver to one part of brass. The silver and brass should be melted together as follows:—Having obtained a broad piece of good charcoal, scoop out a slight hollow on the flattest surface to receive the alloy. Now place the metals in the hollow, and fuse them by means of a blowpipe, using either a jet of gas or an oil lamp with a good broad wick. As soon as the metals become hot, touch them with a crystal of borax (borate of soda), which will immediately fuse, and act as a flux. The jet of flame must now be vigorously employed until the metals are completely fused. The fusion may be continued for a few moments in order to ensure perfect amalgamation. When the "button" of solder is well melted, the flat surface of a hammer may be placed quickly upon it, by which means it will become flattened; in this form it may be readily beaten out (unless a pair of steel rollers are at hand) until sufficiently thin to cut with a pair of jewellers' shears. The solder can be hammered or beaten out upon any solid iron surface; but, as each time the blow is given the alloy becomes harder, it will be necessary from time to time to *anneal* it, *i.e.*, place it again upon the charcoal, and apply the blowpipe flame until the alloy is of a "cherry-red" heat; it must then be plunged into cold water, and is ready for beating out or rolling, as the case may be. The object being to make the solder as thin as ordinary card, or even thinner, when the operator is without a pair of rollers he must use the next best substitutes—a hammer and patience. The solder, before being used, must be scraped with a keen steel edge, and then partly cut into thin strips, and these again cross-cut into small pieces or pellets about one-sixteenth of an inch square. These pellets may be cut when required for use, or kept in a clean box used for the purpose. The operator should next provide himself with a clean piece of slate, say about three inches square, and a small phial filled with water, and having a cork with a small groove cut in it from end to end. The bottle is used to apply moisture a drop at a time, whilst a large crystal of borax is rubbed upon the slate. By this means a thick creamy paste of borax is obtained upon the slate, which will be used as directed presently. The parts to be united or soldered must now be scraped clean *wherever the solder is expected to adhere*, and, with a camel-hair brush or quill feather dipped in the borax paste, brush over the parts to be soldered. A few pellets of the solder may be placed on the dry corner of the slate, and with the extreme point of the brush

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battery. When this is the case, there is evolution of gas from the battery cell. The zinc plate must be withdrawn and re-amalgamated, the part most acted upon being particularly attended to. When a single zinc plate and two copper plates are used, this local action will take place if the copper and zinc elements are too close to each other, in which case the zinc plate generally becomes most freely dissolved towards the centre, but at the upper part of the plate.

58. In order to prevent the zinc plate being *cut off* or dissolved at that part which is between the atmosphere and its contact with the acid solution, it is advisable occasionally to add a little more water to the battery, so as to bring the solution higher up the plate. It is also a good plan to raise the plates a few inches out of the bath occasionally, or to stir the acid solution gently with a stick.

59. When there is a want of activity in the battery (the acid solution being in good order), it may be as well to look to the connections. The binding-screws may require cleaning (a smooth file being used for the purpose, or a piece of emery-cloth wrapped round a flat piece of wood), and the ends of the wire should be well rubbed with emery-cloth.

60. When certain parts of an article require to be gilt whilst others are to be left silvered, it will be necessary to apply certain preparations to the parts to be protected. For this purpose many preparations are used. A solution of gum copal or mastic may be applied with a camel-hair brush; but, unless these varnishes are tolerably thick, they are apt to run. The composition described at page 59 may be used for this purpose, but it will not be safe to use it in hot solutions.

In some cases a strong solution of shellac in alcohol may be used to cover certain parts of an article which require protection.

61. In gilding chains, brooches, pins, rings, and other articles which have been repaired, *i.e.*, hard soldered, sometimes it is found that the gold will not deposit freely upon the soldered parts; when such is the case, a little extra scratch-brushing applied to the part will assist the operation greatly, and I have sometimes found that *dry* scratch-brushing for an instant—that is, without the stream of beer usually employed—renders the surface a better and more uniform conductor, and consequently it will more readily receive the deposit. In fact, dry scratch-brushing is very useful in many cases in which it is desirable to impart an artificial coating of brass upon an article to which silver or gold will not readily adhere. In scratch-brushing without the employment of beer, or some other liquid, however, great care must be taken not to continue the operation too long, as the minute particles of metal given off by the scratch-brush would be likely to prove prejudicial to the health of the operator were he to inhale them to any great extent.

62. In gilding or silvering steel articles by the processes described in paragraph 55, it will be necessary to clean them with a little diluted potash in order to remove grease; and if the articles are polished steel, the friction applied must be brisk, when first employing the solution, to ensure an even coating. Penknives, scissors, razors, and other similar goods may be lightly coated with either gold or silver by the solutions described, but it must be understood that the coating is more for beauty than for wear. If properly done, however, the coating will last a considerable time without removal. Needles gilt and silvered in this way are very agreeable to work with, and form an elegant article for ladies' use.

63. As cyanide of potassium, which is so extensively employed in electro-metallurgy, is a highly poisonous substance, the apartments in which electro-gilding and plating are conducted should be well ventilated, and the solutions always be placed in such a position as to be nearest the window or chimney. Breathing an atmosphere impregnated with the vapour arising from the gilding and plating baths is unquestionably prejudicial to health, therefore the reader cannot be too particular in the matter of ventilation. A little liquid ammonia occasionally poured on the floor is advisable, especially in very hot weather.

64. In reducing old solutions by means of sulphuric acid, it must be borne in mind that the fumes are highly poisonous, and must not be inhaled in the *slightest* degree. The operation should be conducted either in the open air, or where there is a good draught to carry off the fumes. Beyond the current created by an open window and door, there should be no motion in the apartment, so that the fumes may be allowed to escape without being diffused. It must be remembered, however, that the fumes (consisting greatly of carbonic acid) are very dense, consequently it will be necessary to allow them to escape from the *lower* part of an apartment; they must not be expected to make their exit from an aperture *above* them.

65. In "colouring" gold of inferior quality, that is to say, below the English standard (18-carat gold), the following mixture may be used with success, and, if carefully employed, even 12-carat gold may be coloured by it:—

Take

Nitrate of potassa (saltpetre)	4 ounces
Alum	2 "
Common salt	2 "

Add sufficient warm water to mix the ingredient into a thin paste; place the mixture in a small pipkin or crucible, and allow to boil. The article to be coloured should be suspended by a wire and dipped into the mixture, where it should remain from ten to twenty minutes. The article should then be removed, and well rinsed in hot water, when it must be scratch-brushed, again rinsed, and returned to the colouring salts for a few minutes; it is then to be again rinsed in hot water, scratch-brushed, and finally brushed with soap and hot water, rinsed in hot water, and placed in box-sawdust. The object being merely to remove the alloy, as soon as the article has acquired the proper colour of fine gold, it may be considered sufficiently acted upon by the above mixture. The colouring salts should not be used for gold of a lower standard than 12-carat gold, and even for this quality of gold some care must be taken when the articles are of a very slight make.

66. The process of hardening and tempering small steel implements, such as drills, scrapers, gravers, burnishers, &c., may be useful to persons living away from large towns; therefore I have thought it prudent to give an outline of the method to be pursued. The process of hardening and tempering will apply to any steel tool, of any dimensions, but we will take a small chisel as an example. The blade of the chisel should be removed from the haft or handle, and, the lower end being held by a pair of pliers, the blade is to be placed in a brisk fire until red hot; it is then to be removed and allowed to cool for a few moments, and then dipped into cold water. The next thing to do is to file the blade into the required shape, finishing the filing with a smooth file. When this is done (a vessel of cold water being at hand), the blade is to be again returned to the hottest part of the fire, and allowed to become *white* hot, *i.e.*, as hot as a fierce fire will make it; and as soon as this is done withdraw it quickly with the pliers, and plunge it *instantly* into the vessel of cold water. If this has been done properly, on passing a file over the sharpened surface of the blade it will be found to have no effect upon it; in fact, the blade has become so hard that the file will not make any impression upon it. The upper surface of the blade should now be polished by rubbing it upon a sheet of emery-cloth moistened with oil, and then wiped with a piece of rag. The blade now requires to be *tempered*, *i.e.*, reduced in hardness. This is done by holding the sharpened *edge* of the blade with the pliers, and placing it in the fire until the polished surface of the steel changes colour. The surface nearest the handle will soon assume a blue colour, and an orange tint immediately following it, towards the upper end of the blade. At this point great care is required, or the instrument will be overheated and too soft; therefore, as soon as the orange tint makes its appearance within an inch of the sharp edge of the blade, withdraw it from the fire and examine it quickly; if the extreme edge is of a pale straw-colour, dip the blade *instantly* in cold water; but it must be understood that the straw-colour should be visible at the extreme point, or edge, of the tool. When such is the case, the tempering is complete. The next process is to sharpen it upon a good Turkey stone, and it is ready for use. In hardening and tempering very small tools, such as drills, they may be more safely tempered by dipping them, point upward, in hot sand, by which means they are less likely to become over-heated. Some persons prefer dipping such tools into oil rather than water after removal from the fire; others, again, employ dilute sulphuric acid. It must be borne in mind, however, that in hardening steel the greatest heat is required in the first instance, and in the second, the greatest cold we can obtain. Upon these extremes, properly applied, depends the success of the operation.

67. A battery which has been somewhat commended it may be as well briefly to mention. It consists in using a saturated solution of bicromate of potassa, with a quarter part sulphuric acid, in the carbon cell of a Bunsen's battery (see p. 80); and dilute sulphuric acid, or saturated solution of sal ammoniac, in the zinc cell. Although this battery, or rather modification, has some advantages, it has yet to be further developed before it can safely be recommended for practical purposes.

68. A process of coating metals has been suggested by M. Weil, and for some purposes it may be employed with advantage. M. Weil's object is to avoid the use of cyanide of potassium and the battery, the first being deleterious, and the second expensive. His process may be briefly described as follows:—Instead of employing cyanide, he takes solutions of oxide of metals with the addition of organic matter—tartaric acid, albumen, or glycerine, to prevent the precipitation of the oxides by the fixed alkalies. A solution thus formed may be used either hot or cold. For a coppering solution, he recommends the following formula :—

Sulphate of copper	350 grammes.
Dissolve in hot water and allow to cool . .	10 litres.
Crystallized Rochelle salt (potassio-tartrate of soda)	1,500 grammes.
Caustic soda (containing 50 to 60 per cent. free soda)[*]	800 „

The articles are to be suspended by zinc wires, or a thin strip of zinc may be attached to them when in solution; and when it is remembered that this process is independent of the battery, the solution will require renewing from time to time. To accomplish this, M. Weil proceeds as follows :—

The zinc which the solution has acquired must be precipitated by sulphide of sodium (prepared by fusing soda with sulphur) gradually, as an excess dissolves the precipitate formed by the sulphide of soda. When the zinc has been precipitated as above directed, the solution must be allowed to settle, and the clear liquor poured off. The solution is then to be resupplied with a solution of sulphate of copper, as before.

It is stated that copper deposited in this way adheres very firmly to iron.

Zincing by the above process is carried out by forming a concentrated solution of potassa or soda, which must be heated to 100° C., a piece of metallic zinc being placed in the solution in contact with the article to be coated.

True bronze, that is, a mixture of tin and copper, may be deposited by the above process, by adding to e copper bath before described stannate of soda or chloride of tin, previously treated with the solution of da. The metal to be coated must be in contact with nc.

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[*] Caustic soda is prepared by dissolving 12 parts of ordinary soda in hot water, and then adding, gradually, 2 parts of lime recently slaked. The liquor should be boiled for an hour, and allowed to cool and settle; the clear liquor being decanted for use.

69. A new constant battery has been suggested by r. A. Reynolds, in which a solution of perchloride of on is used as an exciting fluid, and metallic iron as e positive electrode.

70. Copper may be coated with antimony, as fol- ws :—Dissolve 1 ounce protochloride of antimony (but- r of antimony as it has been called) in 1 pint of spirit wine; now add hydrochloric acid until the solution is ear. The article to be coated, being previously cleaned, ill receive a bright coating in about an hour. Cast on must be previously coppered by any of the pro- sses before described, and will then receive a coating antimony from the above solution.

71. As the refining of gold and silver is so closely nnected with the electro-plater's art, the following nts may prove serviceable, it is hoped, to those unac- ainted with the art of separating the precious metals om their alloys. An alloy of gold, silver, and copper, ould be thus treated :—Suppose the alloy to be what called "jewellers' gold," or the material with which eap jewellery is made, and which, being unfit for use, "only fit for the melting-pot." The alloy is first to e melted in a crucible with one-third of its weight of lver, a little dried potash or borax being used as a ux; when the alloy is well melted, it is to be poured to a vessel of cold water, which must be briskly stirred uring the operation; and it is well to have a few small ieces of straw, or short sticks, floating on the surface f the water at the time, the object of which is to assist the process of *granulation.* The alloy will now be found at the bottom of the vessel in small grains, which must be carefully collected, and in order to be certain that there is no waste, the alloy should be weighed before and after melting and granulation. With ordinary care scarcely any difference will be observed. The grains must now be put into a clean Florence flask, or other suitable vessel, and dilute nitric acid (1 part acid to 2 parts water) poured upon them: the grains should be allowed to digest for several hours; and, in order to promote chemical action, it will be advisable to place the flask upon a "sand-bath" or near the fire, but this may not be necessary until towards the end of the operation. The gold will now be found at the bottom of the flask, in the form of a brown powder or brown spongy lumps; but, in order to secure the entire removal of the alloys, it will be necessary to decant the solution of silver and copper in the nitric acid into a separate vessel, to be afterwards treated, and fresh nitric acid should then be poured on to the gold, and heat applied as before, to ascertain whether the alloys have been effectually removed. If *red fumes* are still given off in the flask, the separation has not been complete, and the action must be kept up until the red fumes cease to appear even at a boiling temperature. When this is the case, the acid solution must be again poured off, and the gold well washed with hot water, to remove any trace of silver or copper which may be in its interstices, especially if it is in a spongy form. At this stage the brown deposit or mass of gold is pure, and merely requires to be melted into a button with borax or potash.

The solution of silver and copper may next be treated—the silver being thrown down by strips of copper; and, to ascertain whether *all* the silver has been precipitated by the copper, a small quantity of the solution may be placed in a glass, and a drop or two of hydrochloric acid or a solution of common salt applied; when, if any silver remains in solution, it will assume a milky appearance; if such is not the case, the cupreous liquor may be poured off, and the reduced silver well washed with hot water several times. The silver should then be dried and fused, a little dried potash being mixed with it previous to placing it in the crucible. The silver may then be granulated, as before, or cast in a mould of suitable size; and, being rolled out, will serve as an anode.

It must be understood that the above is but a trifling sketch of the principles of refining in the moist way; yet it is hoped that the reader will learn therefrom enough to enable him to pursue the art of separating gold and silver from their alloys for his own purposes.

When gold and silver are alloyed, or mixed with copper, brass, iron, &c., as in the case of jewellers' waste, filings, &c., the waste, being previously burned in an iron pan to destroy any organic matter present, should be well mixed with a little dried potash, and melted in a crucible. When perfectly fused, a few crystals of nitrate of potash (nitre of commerce) must be dropped into the crucible from time to time, which will remove from the gold and silver whatever copper or iron may be present, if sufficient nitre has been employed. The nitre must, however, be added cautiously; otherwise, if there be organic matter present, the flux may rise above the melting-pot, and, overflowing, carry part of the metal with it. It will be necessary to watch the operation closely, and if the flux, &c., appear likely to overflow, a small quantity of dried common salt thrown into the crucible will check the ebullition, and tend to keep the metals and flux to the lower part of the vessel. When the operation is complete, the melting-pot or crucible must be withdrawn from the fire and set aside to cool. When cold, the pot must be broken at the base with a hammer, and the "button" of metal withdrawn. The button must now be again melted, as before described, with borax or potash, and granulated, the grains being treated as before, to remove the silver and copper.

As the above details are intended for the use of those who may be unacquainted with the art of refining, it is hoped that they may be found sufficient to enable the beginner to commence a study of a most interesting and important branch of industry.

72. Cyanide should seldom be added to a bath, whether of gold or silver, when the anode, being at work, is clean and uniform in appearance. It is always objectionable to have too great an excess of this salt in the bath; therefore it should never be added until the batteries and their connections have been well examined. Sometimes, when the battery is somewhat exhausted, the anodes become slightly discoloured, especially if a larger surface of goods is exposed than is proportionate to the surface of anode; in such case, it will be necessary to increase the activity of the battery rather than to add cyanide to the bath. Cyanide is a good friend, but a bad foe. All that a good bath requires is a slight excess of cyanide, if the battery is in good order and but little organic matter has accumulated in the bath. When, on the other hand, the bath has acquired a good deal of organic matter (under which condition it is generally preferable to a new bath), it will require a greater excess of cyanide, and this excess, under such circumstances, will be very beneficial. An old or well-worked bath will bear a much larger amount of cyanide, in proportion, than a new one.

73. Old steel dessert-knives, which have been "close-plated," or solder-plated, as it is termed, will sometimes give the operator a good deal of trouble before he can deposit a sound coating of silver or gold upon them. Suppose the old silver has been stripped off, and the solder removed, the author has more than once found that a very serious difficulty has arisen when the articles have been coated either with gold or silver, or with copper, previous to coating with the other metals. For instance, a dozen dessert-knives, having been stripped and well cleaned, were placed in the alkaline copper bath. After an hour's immersion, the articles were removed from the bath and examined, when it was found that in every part of each blade, from heel to point, the blades were found to be *cracked*, exhibiting fissures in some cases nearly $\frac{1}{16}$th of an inch wide. These cracks pervaded each blade in almost every part, and it was some time before the cause of these remarkable flaws could be traced. In examining the interior of the cracks, it was found that the copper was freely deposited, and, the coating becoming thicker and thicker, the deposit of copper *forced open* the cracks (although at first invisible), until they assumed the alarming appearance we have described. It must be remembered that the numerous *points* which the fractured metal presented would greatly favour the deposit in those parts, in preference to the plain surfaces, and hence the opening of the invisible flaws in the metal as the deposit thickened. The same result has occurred in certain articles of wrought steel of bad quality; and when we bear in mind that the processes of grinding and polishing disguise such defects in steel, it must not be expected that they will show themselves until some time after deposition has begun. In order, however, to prevent, as far as possible, the flaws we mention from opening during deposition, we recommend that the first coating should be allowed to take place almost immediately after the article is immersed in the bath, and as soon as this is done, the article should be quickly rinsed, scratch-brushed, and returned to the bath. Again, it will be advisable to employ a tolerably weak bath at first, with good battery power, and after the articles have received a preliminary coating under these conditions, they may then be more safely allowed to remain in the bath until the required amount of metal is deposited.

74. When wooden vessels are employed for plating, they should be well saturated in boiling water for a few hours, or even days, before the solution of silver is poured in; as, independent of the absorption of silver by the wood, if it is well moistened with water, the interstices are not so readily acted upon by cyanide.

75. Gutta-percha vessels or linings of gutta-percha should never be used for a silver bath under any circumstances, as the cyanide acts upon gutta-percha and the adulterants with which it is always, more or less, contaminated. Nitrate of silver, also, acts upon gutta-percha, as most photographers are aware; and, therefore, it will be absolutely necessary to avoid using gutta-percha in contact with either cyanide of potassium or nitrate of silver. I have known more than one instance in which a silver bath, being destroyed by a gutta-percha lining, has been reduced by sulphuric acid; and, soon after the acid has been applied, the gutta-percha has been set free, and has floated in the solution in clots of considerable size.

76. When the operator's hands have become injured by coming in contact with cyanide (which is frequently the case if there is an abrasion of the skin), it is a good plan to dip them for a few moments in very dilute sulphuric acid (20 drops in a tumbler of water), and then rinse them well. The hands should then be well soaked in tolerably hot water, well dried, and finally saturated with oil or grease of some kind. The author has frequently suffered from sores occurring under each nail of both hands, in consequence of neglecting to wash the hands immediately after immersion in a solution of cyanide. The electro-plater should be careful to avoid this, as sores thus formed are difficult to heal, and cause great pain to the part affected.

77. Copper or brass wire should never be bent or twisted more than once or twice without being annealed. When the wires used for slinging goods, or the wires proceeding from the electrodes of a battery, have been used more than once, they are apt to become brittle where they have been bent, and are liable to break; it is better, therefore, occasionally, to make the wires red hot, and, when cool, stretch them out by drawing them several times across the edge of a board, by which means they will readily become straightened. The wires should then be passed through a piece of emery-cloth, to clean them. The ends of slinging wires, however, which have become coated with silver, should first be dipped for a few moments in the hot stripping solution (p. 56), and finally treated as above.

78. The moment the zinc plate of a battery evolves gas, accompanied by a hissing noise, the plate should be withdrawn and at once re-amalgamated; for, as soon as local action sets in, the current becomes greatly diminished; added to which, if allowed to continue, the zinc plate will soon be destroyed, without accomplishing its task. It is not uncommonly the case that local action begins on the first day that a battery is set in action; and, therefore, in order to remedy this defect as early as possible, the battery should be carefully watched, and the zinc plate removed the instant effervescence is observed in the battery-cell.

79. In order to ascertain whether an article is made of gold, if a doubt arises, a simple plan is to rub a portion of the article upon a piece of slate, Wedgewood ware or Turkey stone, and then apply a single drop of nitric acid by touching the part with the stopper of the bottle. If the acid produces no effect, the article may be considered gold. A very inferior alloy of gold, however (12-carat gold), will stand this test; but its colour will act as a guide, as it will fail (except when electro-gilt) to present the rich yellow colour of good gold. When a "common gold" article has been strongly gilt, it will be advisable to pass a keen but smooth file over a small part of the article, and then apply the nitric acid to the part, when, if the article is not genuine, the characteristic green tint of nitrate of copper will at once show itself. As it is commonly the practice to designate articles manufactured from "plated" metal (*i.e.*, gold and metal united and rolled out into thin *sheets*) "fine gold," the electro-gilder should make himself acquainted, if he is not so already, with the various kinds of genuine and spurious gold in commerce; otherwise, should an accident occur to an article, he may lose more than he has a right to do; and, again, *plated* articles require a somewhat different treatment to that which is applied to articles of genuine gold. In applying the term "genuine gold," we suppose we must be understood to mean such articles as are made of an alloy of gold which *will* stand the test of nitric acid, if only to contradistinguish them from plated-gold articles. An instance once occurred to the author in which, by mistake, he placed two "gold" brequet or Albert chains in a jar containing nitric acid, instead of dipping them into a vessel of warm water, which stood beside it. Being away for an hour, on returning to the gilding-room it was found that the nitric acid had entirely removed all trace of the brequets, except a thin shell of one of the links, which floated upon the surface of the acid, and a dark-brown powder which had deposited in the vessel. On pouring off the acid, and washing the precipitate, which was found to be almost pure gold, it at once became evident that the so-called gold brequets (which had been invoiced at 55*s.* 6*d.* each, wholesale price) were, in fact, made of *plated* metal, but of so good a quality that a very good judge might readily have been deceived. The object of the above remarks is to place the electro-gilder on his guard. He should also endeavour to satisfy himself whether an article is really gold, or an alloy of gold, or plated, before preparing it for the bath, as, if it is gold, it will require as a rule a rather stronger current, and a larger surface of anode exposed in solution, than an article made of plated metal.

80. The back parts or hollows of casts, or "struck" work, will sometimes be troublesome to gild or silver, more especially because these surfaces must of necessity be kept at a distance from the anode, and besides which a concave surface (even if placed directly facing the anode) always receives the deposit more tardily than a convex surface. It will be necessary then, in order to aid the deposition upon the hollow surfaces, to keep the articles moved in the bath when first immersed, by which means all surfaces will receive the deposit alike, and the deposition which takes place after will be in the order required—that is, the outer surfaces will receive the greatest amount of metal, and the inner surfaces, or hollows, the least, but still sufficient for all purposes. If this precaution is not adopted, it is quite possible that the exposed surface of the article will be well coated, whilst the hollows will scarcely be coated at all. Nothing ensures uniformity of deposit so much as gentle motion in the bath, and in some manufactories an apparatus has been applied for keeping articles, while suspended in solution, in a constant but gentle state of motion—a practice very highly to be commended, upon principle, if it can be carried out with economy.

81. The effect of *motion* whilst an article is receiving the deposit is most clearly seen during the operation of gilding. If a watch-dial, for instance, is placed in the gilding-bath, and allowed to remain for a few moments undisturbed, if the solution of gold has been much worked, it is probable that the dial will acquire a dark red or "foxy" colour; but if it is quickly moved about, it instantly changes colour, and will sometimes even assume a pale-straw colour. In fact, as we have before observed, the colour of a deposit may be regulated greatly by motion of the article in the bath—a fact which the operator should study with much attention when gilding. In depositing brass from its solutions, the effects of motion are even more remarkable; for, by keeping the articles moved, copper alone will be deposited, whilst, on the other hand, if stationary, a proper alloy of copper and zinc will be obtained.

82. As there is always a deposit or sediment of some nature at the bottom of a bath, whether of gold or silver, the articles to be coated should never be immersed so deeply in the solution as to come in contact with this deposit. If spoons and forks, for instance, are allowed to reach nearly to the bottom of the bath or solution-vat, every time they are lifted up or lowered the small particles which had settled at the bottom of the vessel become disturbed, and resting upon the articles, will prevent the deposition of silver taking place wherever these particles are present, thus causing an irregularity of surface. As it frequently happens that small particles of silver fall off the surface of the anode, these will sometimes, if the sediment is disturbed, as we have pointed out, rest upon the lower parts of the work, and the deposit will take place *over* them, and when submitted to the scratch-brush the silver will strip or peel off; or, if the deposit is very thick, the bowls of spoons or prongs of forks, or such surfaces as are nearest the bottom of the bath, will be exceedingly rough, more especially as deposition always takes place more freely at the lower surface of the solution. There should, therefore, always be a certain distance between the lower end of articles in solution and the bottom of the vessel in which they are coated.

83. As pure silver is more easily oxidised, or tarnished, than standard silver, electro-plated articles should always be carefully protected from the atmosphere, especially if it be moist or vitiated. Electro-plated goods must always be kept well wrapped up, and in a perfectly dry situation; otherwise oxidation soon sets in, and the goods become unsightly and unsaleable.

84. Although a silver bath is improved by acquiring a moderate amount of organic matter, yet the operator should be careful not to suffer this accession to the bath to take place either too suddenly or in large quantities at a time. For instance, if candlesticks, which generally are filled with a compound of rosin or pitch, are placed in the solution without being previously freed from these substances, the cyanide will dissolve a considerable portion of the composition, and the conductibility of the solution is thereby lessened to some extent. In a moderate degree, the presence of such matter in a bath is an advantage; but it should never be allowed to enter the bath in large quantities at a time. A new bath which suddenly acquires a quantity of organic matter in the way we have described is apt to work sluggishly and with irregularity, and not unfrequently the deposit becomes coarse and spotted. On the other hand, a bath which in the course of several months has absorbed a small amount of organic matter (which will cause it to assume a dark-reddish colour) will give a much finer and brighter deposit than a bath newly made; and, at the same time, goods plated in it will be less liable to strip than when plated in a new bath.

The same observations do not apply to a gilding bath, which is generally worked hot, and, besides which, the colour of the deposit is of the first importance. The presence of organic matter in a gold bath tends to deepen the colour; and if in great excess, the work will frequently assume a foxy-red tint, and this, in some cases, would be highly prejudicial. It is better, therefore, to keep the gold solution as free as possible from organic substances; and as one of the chief causes of a gold bath acquiring organic matter is the *imperfect rinsing of articles after scratch-brushing*, whereby the beer used in the operation of scratch-brushing becomes washed out of the interstices of the article when in the bath, it is advisable not only to rinse all articles well before gilding, but in fact they should always receive a final rinsing in perfectly clean hot water. It is not an uncommon practice for electro-gilders to rinse many articles, after being scratch-brushed, in the same water, and to transfer them directly to the gilding bath. Now this is highly objectionable: the water should be frequently changed, and when we consider the difference between investing a little trouble in renewing the rinsing water and making up a fresh gold solution, it will at once become apparent that the former will be most likely to yield an advantage. Again, a gold solution which has been worked a long time without becoming discoloured (the discoloration generally being due to organic matter) is far better than a new solution, and, for most purposes, will produce better results; but as soon as the solution becomes charged with the impurities referred to, its action is uncertain and irregular. It is to be hoped that the less practical reader will bear these observations in mind, that he may experience as little disappointment as possible in his operations.

85. As lead edges or mounts of cruet-frames, candlesticks, soy-frames, and similar plated goods are very troublesome to electro-plate, except in the hands of a very experienced person, it is frequently advantageous to adopt a plan commonly pursued, namely, to have the edges cast in brass or German silver, the old edges or mounts removed, and the newly-cast edges soldered upon the article. By this means all difficulty is removed, and the article, when finished, is not only rendered more durable, but can also be more highly finished.

86. It is a good plan for the operator to secure impressions in gutta-percha of all mounts, or parts of the same, which are likely to become serviceable to him at an after-time. These impressions can be electrotyped by the processes described in the early part of this work, and at any time castings can be made from them which may be applicable to many useful purposes. For instance, if an impression of a few inches of a gadroon mount be taken, and an electrotype obtained therefrom, and a few castings made from the electrotype, whenever the operator requires a few inches or even a part of an inch of such a mount, to supply the place of a broken gadroon edge, he will find the castings of great service to him. And by adopting this practice, it is possible not only to accumulate copies of very useful, but of many very choice mounts. And from these electrotype copies many beautiful and useful articles may be formed by carefully grouping the impressions obtained from various articles, or parts of them, to form a new design of an entirely novel character. The author has produced some very pleasing effects by arranging alternately, for instance, a piece of scroll-work an inch and a quarter in width, and a cornucopia of equal width, the latter being about two inches long. Four impressions of each being taken, and soldered together, formed a handsome octagonal salt-cellar. A circular ring of wire, connected by short pieces of wire to the inner surface of each "upright," formed a resting-place for the glass or salt vessel, which may be made either of blue, red, or white glass, according to taste. From the above hints the reader may glean sufficient to enable him to construct, upon the same principle, many articles of great beauty, and at the same time possessing novelty of construction, if not of design. Impressions of very rare subjects may be taken and applied in this way, and there is scarcely a limit to the variety of effect which may be produced.

87. A very pleasing effect may be produced upon a plain silver article, by sketching a design upon it with a good lead pencil—a name or initials, for example—and if the article is then placed in the gilding-bath for a few moments, all parts which have not been traced by the lead pencil, will have become gilt. When the article has been rinsed, gentle rubbing with the finger will remove the plumbago, or "black lead," and beneath the design will appear in silver. By reversing the operation, the design may be made to appear in gold. Plumbago answers well for this purpose, owing to its being an inferior conductor to either gold or silver, especially in alkaline solutions. In practising this process, however, care must be taken not to move the articles while in solution, otherwise the plumbago may be worked off by friction, and, consequently, the design will be obliterated by deposition taking place where the design appeared.

88. When several articles made of different metals are to be plated in the same bath, the article which is the worst conductor should be put in first. Thus, supposing copper, brass, and German-silver articles are to be immersed, the copper article should be suspended first, the brass next, and the German silver last. At the same time, the anode must be slightly lowered as each article is suspended. If convenient, it is better to plate articles composed of one metal or alloy only, at the same time.

89. Bichloride of mercury in solution has been recommended for amalgamating zinc plates instead of the ordinary method, and, in many respects, it would appear to present an advantage. But if zinc plates are cast from a mixture of zinc and mercury, they would be still more effective and durable, and less liable to local action. The alloy of zinc and mercury consists in melting zinc in the ordinary way, occasionally adding a little grease, rosin, or sal ammoniac, and, when melted, pour in gradually mercury in the proportion of—1 ounce of mercury to each pound of zinc. Zinc thus alloyed is exceedingly brittle, and the plates will therefore require careful treatment. If well prepared, however, these plates possess many advantages over the ordinary amalgamated plates.

90. All old plated articles which have to be pumiced or rendered smooth with Water-of-Ayr stone, or otherwise prepared for plating with the aid of water (that is to say, not being rendered smooth by emery-cloth, &c.), should have a vessel kept specially for them; for instance, a wooden tub with a board placed across, in order that the particles of silver rubbed off by the pumice, &c., may be collected in the vessel beneath; and the electro-plater cannot be too careful in saving this and all other kinds of waste, either of gold or silver. Many persons who have omitted to save this kind of waste from the commencement of their operations have nurtured the idea that it was useless (having lost so much already!) to begin to save such comparatively trifling waste; but we would strongly impress upon the student the great importance (when dealing with the precious metals) of using the utmost economy. Gold and silver are always recoverable, in some shape or other; therefore, to allow them to escape down a gutter beyond the power of recovery (as many photographers do) is not only foolish, but wicked.

91. A good conducting surface may be given to gutta-percha, wax, or other non-conducting material used in electrotyping, by employing precipitated silver. This may readily be formed thus: Make a solution of nitrate of silver, and place in it a few pieces of clean sheet zinc; in a few hours the silver will be thrown down in the form of a grey powder. Any silver which may adhere to the zinc can be easily brushed off. The precipitate (which is fine silver) must be well washed with hot water, and then carefully drained on a filter of blotting paper; it is then to be well dried at a gentle heat, when it is ready for use, and may be employed in the same way as plumbago.

92. Any good metallic bronze, but more especially copper bronze, will form an excellent conducting surface on gutta-percha or wax. The bronze known as Bessemer bronze is admirably suited to this purpose.

93. Copper ribbon may be advantageously substituted for copper wire, more especially when large electrotypes have to be formed.

94. When a mould presents many hollows or cavities it is advisable to employ "guiding wires," as they are termed, to aid the deposit on these surfaces. For instance, a bunch of thin copper wires may be twisted round the negative electrode, close to its junction with the mould, and these wires should then be bent and allowed to touch each hollow or cavity, so as to favour the deposit at those parts. A very little practice will soon make the operator skilful in this matter.

95. A very good alloy for zinc bars (for battery purposes) may be made by putting half an ounce of quicksilver to each pound of zinc in the crucible. The zinc bars should be well amalgamated all over before using, and they will retain their uniformity for a considerable time without any further application of mercury.

96. It has been suggested to melt wax and litharge (oxide of lead) together to form a good composition for electrotype moulds. Take 1 pound of wax, and 1 ounce of litharge; fuse them in a pipkin for half an hour; then allow the litharge to subside, and pour off the clear liquid and set aside to cool until wanted. This composition is supposed to be less liable to contract when passing from the fluid to the solid state.

97. When the "single cell" arrangement (*vide* p. 14) is employed for electrotyping, a stronger solution of sulphate of copper may be used than that before described. For instance, take 1¼ pound of sulphate of copper, half a gallon of hot water, and dissolve. Then add 1 pint of cold water acidulated with 4 ounces of sulphuric acid. The solution should be allowed to stand for some hours until quite cold, and the clear liquid separated from any sediment that may be present, when it will be ready for use.

98. When fusible metal is employed for making moulds, care must be taken that the ingredients with which it is composed (p. 25) are well blended together. This is best secured by re-melting the alloy several times. When first melted, pour the alloy in detached globules on an iron slab, or a piece of slate will do, and when cold re-melt them. Do this several times, to ensure perfect mixture.

99. When a very stout deposit of copper is required for an electrotype, copper filings may be sifted over the deposited metal (provided the deposit is perfect), and the electrotype is then returned to the bath to receive an additional coating. The deposit will unite with the copper filings, when fresh filings may be added again and again, the mould being placed in the bath each time until the required thickness is obtained.

100. Instead of adding sulphuric acid to the saturated solution of sulphate of copper as described at p. 15, Glauber's salt (sulphate of soda) may be substituted. Take, say, saturated solution of sulphate of copper 2 parts, Glauber's salt 1 part, dissolved in sufficient cold water. The two solutions are to be well mixed together.

101. There are few articles with which the electro-metallurgist has to deal that are sold in a less pure state than the ordinary cyanide of potassium; and in order that he may be able to estimate the money value of commercial cyanide, we give the following method, suggested by the late gifted Thornton Herapath, of Bristol:—*

"The first thing to be done in testing cyanide of potassium is to prepare a standard solution of ammoniosulphate of copper or ammonio-nitrate of copper. A certain known quantity of pure crystallized sulphate of copper, made by crushing the pure crystals of the shops in a mortar and pressing the powder so obtained between folds of bibulous paper, is taken and dissolved in water. The solution so prepared is then to be diluted with water so as to measure 2,000, 3,000, or more water grain measures at 60° F. Supposing 390·62 grains of the pure sulphate to have been taken and diluted to 2,000 grain measures, every 100 grains of such solution will, of course, represent 5 grains metallic copper, or 6·25 grains of the protoxide of copper; 100 grains of each of the samples of cyanide of potassium to be tested are then dissolved in a sufficient quantity of water, and introduced into the colorimeters; an excess of ammonia is added, and the standard solution of copper is carefully added (out of a graduated burette) to the contents of each colorimeter in turn, until a faint blue coloration makes its appearance in each of the solutions. The quantities of copper, or of the solutions taken, then indicate the relative strength and money value of the samples of cyanide examined. Suppose, for instance, one specimen took 100 measures, and a second 150 measures of the copper solution, the relative strengths and values of such specimens are, therefore, as 100 to 150, or 2 to 3."

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* *The Chemist*, vol. iii., p. 385.

In order to render the above process available in the determination of the actual strength of, or proportion by weight of, pure cyanide of potassium existing in the commercial cyanides, it is only necessary to obtain a small sample of *pure* cyanide and to ascertain how much of this is required to decolorize 1 grain of copper in the form of ammonio-nitrate.

102. To those who use jewellers' rouge (red oxide of iron, or *colcothar*) in large quantities, and to whom its extreme fineness is of the first importance, the following process for its manufacture will be found highly serviceable. By the ordinary methods of making rouge much care is required not only to free it from acid, but also from hard particles which would be highly injurious if not effectually separated from the article in the process of manufacture. To M. Vogel, jun., of Munich, we are indebted for the process referred to, which is not only simple but certainly effective.

Into a solution of sulphate of iron, made with boiling water and filtered, pour a concentrated solution of oxalic acid, until no more yellow precipitate of oxalate or protoxide of iron is formed. When the liquid is quite cold, and deposits nothing more, the precipitate is washed on a cloth with hot water until the washing water no longer gives an acid reaction upon blue litmus paper. The oxalate is afterwards well drained, and heated in the partially dry state on an iron plate, or in a boiler of the same metal, over a small charcoal fire, or even a spirit lamp. The decomposition commences at the temperature of 392° F., and on raising the temperature a little the red oxide of iron is formed, and is found in the finest possible state.

The rouge thus formed affords the most perfect security of the finest division of the product, and may be employed with the greatest success in polishing either gold or silver, and it has been found invaluable in the polishing of plate-glass, Daguerreotypes, and optical instruments.

103. M. Vogel, jun., also turned his attention to the substance known as "putty powder" (oxide of tin), which he prepares by the following simple process:—

A solution of commercial chloride of tin is prepared by pouring on 1 part of the salt 6 parts of boiling distilled water, and the solution is filtered through a cloth into a cylindrical glass vessel in order to keep back any foreign substances with which the chloride may be contaminated. Into the still hot and almost clear solution of chloride of tin is poured a concentrated solution of oxalic acid; a white precipitate of oxalate of protoxide of tin is formed. After complete cooling, the liquor is decanted, and the precipitate washed on a linen cloth with cold water until the washings no longer give evidence of the presence of acid on litmus paper.

The oxalate of tin is now to be heated, dried on an iron plate, or in a boiler of the same metal, over a small charcoal fire. The decomposition of the salt commences at red heat, and there remains; after the disengagement of carbonic acid gas and carbonic oxide, a quantity of oxide of tin is found in a state of extreme division.

During the decomposition—which must be accelerated by stirring with an iron wire—the matter undergoes a considerable increase in bulk; consequently, it is necessary to employ for this operation very spacious vessels, so as to avoid loss of product.

With regard to quantity, we obtain 1 part of oxide of tin by employing 2 parts of chloride of tin and 1 part of oxalic acid.

It will be obvious that by the above processes each of the products will be in the form of an impalpable powder, which is of the greatest importance in polishing metallic surfaces.

104. Electrotypes may be bronzed by suspending them in a wide-mouthed bottle, at the bottom of which *a small* quantity of sulphide of ammonium has been placed. The sulphide of hydrogen which escapes will give a good bronze tint to the copper in a few moments, the depth of tone being regulated by the time of exposure.

105. A very good elastic moulding material for copying objects which are very much *undercut*, may be made by dissolving 1 pound of gelatine in three-quarters of a pint of water, over a slow fire; when dissolved, add half an ounce of beeswax cut up in small pieces. This mixture should be warm, but not hot, when used. Before applying elastic moulding materials plaster casts should always be carefully brushed over with oil.

106. Glass vessels may be coated with copper by the electrotype process, by simply varnishing the outer surface of the vessel, and when the varnish is *nearly* dry, brushing plumbago well all over it. A conducting wire is then attached to the varnished surface, which may be conveniently done by employing a small piece of softened gutta-percha or beeswax—taking care to apply the plumbago to the part which unites the wire to the plumbagoed surface.

107. In no case should an electrotype be removed from the mould until a sufficiently stout deposit has been obtained; otherwise the operator may be disappointed by finding the copy break while he is separating it from the mould.

108. It is a good plan to allow amalgamated plates of zinc to dip into a shallow vessel containing mercury; this vessel should be placed at the bottom of the battery jar, and the plate allowed to rest in it while the battery is in action. This will keep the plate well amalgamated for a long period, if the process of amalgamation has been efficiently carried out in the first instance. The evolution of gas at the plate will always indicate when undue chemical or "local" action takes place, when the plate should be at once removed and re-amalgamated.

109. Decomposition troughs for electrotyping may be very conveniently made by those who live in districts where chemical apparatus is not easily obtainable, by the following plan. Obtain four pieces of plate glass, say two pieces 12 in.×6 in., and two pieces 8 in.×6 in. These plates of glass may be readily united by Canada balsam, melted gutta-percha, or marine glue—the two shorter plates being so placed as to form the ends of the vessel. A piece of stout board, 13 in.×9 in., forms a bottom, and the glass vessel may be cemented to this first with Canada balsam, and lastly by pouring melted pitch or asphaltum round the interior of the vessel, where the glass and wood unite. Softened gutta-percha, fused on by means of a moderately-heated poker, will be a very secure and simple substitute for the pitch. A glass vessel thus constructed will last for years with moderate care, and is admirably suited for electrotyping purposes. Plating solutions containing cyanide of potassium, however, should not be placed in vessels which are made of detached materials, as the substances employed to put them together are generally soluble in cyanide, not excepting gutta-percha. In a vessel of the size above given, several electrotypes may be made at the same time with a battery of tolerable power. When several electrotypes are to be produced in the same decomposition trough, the moulds should be suspended from a brass or copper rod connected with the negative pole of the battery, and a stout sheet of copper (connected with the positive pole of the battery) is to be suspended in the copper solution immediately facing the moulds to be copied.

110. When the mould is first placed in the solution of copper, only a *very* small surface of the copper anode should be immersed at first—a surface about equal to the amount of wire attached to the mould which is in solution. This precaution will prevent the deposit taking place too rapidly at the junction of the wire with the mould—a very important matter to avoid, since otherwise the copper might become deposited in the state of a powder, instead of in the proper reguline condition. And, again, the battery power must not be too vigorous at first, or the deposit will take place too rapidly at the point of the wire, assuming a dark-brown colour, of a powdery texture. When the deposit has commenced properly, a bright red layer of copper will start from the point of the wire, radiating gradually on to the plumbagoed surface. After awhile, the anode may be lowered gradually, thus augmenting the surface *in solution* as the deposit progresses. When the mould is thoroughly coated, the battery power may be increased, and the surface of anode in solution augmented also.

111. Those who are unable to procure porous cells of any given size at a time when they are most in need of them, may render themselves independent in this respect by manufacturing these things for their own use by a very simple method. For this purpose, a bag of coarse plaster-of-Paris, a thin sheet of tin, or a sheet of pasteboard and some sealing-wax or shellac will be required. Having determined what size the porous cell is to be made, a round wooden roller (such as silks are rolled upon, and which may be obtained from any linen draper) is procured, and this is to be employed as a *core*, thus:—Make an artificial shoulder say 12 inches from one end of the roller, by binding about six strips of thin card, one above another, round the roller. These pieces of card should be about an inch in width, and each succeeding strip or layer must be cut longer as the circumference increases, so as to form a perfectly round shoulder. A piece of thin sheet-tin or pasteboard, say 13½ in. long, is now to be tightly bound round the shoulder, to form a tube or case, and the edges of this outer case may be further closed by sealing-wax—taking care that the roller does not touch the outer case. In order to render the core easy to remove, the wooden core may be covered with a layer of foolscap paper, pasted at its edges, and overlapping the end; the paper should be well oiled. The mould being now ready, a sufficient quantity of plaster-of-Paris is to be worked up *quickly* into a thin paste, and, the mould being inverted, the plaster is to be carefully but promptly poured in, taking care that there are no air bubbles, and that the plaster reaches the extreme open end of the tube, which is to form the bottom of the cast. When all the plaster is poured in, the mould should be held upright until the plaster has "set," which it will do in a few minutes. It may then be put aside for an hour or so, when the core may be withdrawn, gently, and the outer case removed. Should the paper in which the case was enveloped still remain in the mould, this may be easily removed by gently pulling it away; or, should it prove obstinate, when the porous cell has become *quite hard*, a little hot water and soda will soon render it easy to remove, by converting the oil into soap and the paper into pulp. The porous cell should then be rinsed, and after trimming its rough edges with a knife or a file, the cell is ready for use. By shifting the shoulder, porous cells of more or less depth may be made at any time. A little practice will soon render the operator expert in porous cell making.

112. In coating steel or iron articles with nickel, deposition should not be allowed to take place too rapidly at first, otherwise the metal will be liable to strip. The battery power should be moderate, and the surface of anode in solution only sufficient for the deposition to take place at once, but not too vigorously. When the articles have become coated the anode may be lowered gradually, and after awhile the battery power may be moderately increased; this must be done with judgment, however, as a good reguline deposit of good colour depends greatly upon the nature of the current employed, and the amount of anodal surface exposed. It is also of the greatest importance that articles of steel or iron should be placed in the solution-bath *immediately* after they have been cleaned, as even a few moments' exposure to the air or immersion in water is quite sufficient to cover them with an invisible layer of oxide, which would prevent the nickel from adhering closely to the other metal. On the other hand, it is important in coating steel or iron articles with nickel, not to suffer deposition to take place too slowly when they are first placed in the bath, as they are apt to strip from this cause also. When convenient to do so it is a good plan to scratch-brush the articles after they have received a thin coating, by which the subsequent deposit is rendered far more liable to adhere. The author has always found, when coating either steel or iron with other metals, that the scratch-brush has been his best friend; and the labour bestowed has given ample return in the shape of a good adhesive coating to these rather refractory metals.

113. When precipitating zinc or copper by sulphide of hydrogen from acid solutions of nickel, as, for instance, in cases where commercial, and not pure, nickel has been used, it is of the greatest importance to observe two essential conditions of the liquid treated. 1. If the acid solution contains a large excess of acid it is exceedingly probable that a small portion of zinc will continue in solution, even though the stream of sulphide of hydrogen may have passed through the solution for several hours. 2. If the acid solution is highly concentrated, it will be almost impossible to get rid of every trace of the zinc. The conditions which most favour the *complete* separation or precipitation of the zinc are, the solution being only moderately acid, and tolerably dilute. Copper is more readily thrown down by sulphide of hydrogen than zinc, and the absence of its characteristic colour is sufficient evidence that there is none of this metal in solution. The sulphide of hydrogen, whilst it leaves the nickel in solution, will readily precipitate either antimony or iron, should the nickel have been alloyed with either of these metals; but the solution must be slightly acid at the time, otherwise the nickel also will be thrown down.

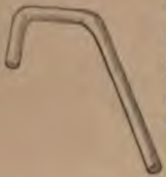
114. Britannia metal, or pewter articles which are to be coated with nickel, require different treatment to insure a good degree of success, because these softer alloys require vigorous battery power in order to induce the deposit to take place promptly. At the same time it is advisable, *provided the deposit takes place immediately after immersion*, to remove the pewter or Britannia metal about in the solution gently, so as to ensure a uniform coating, and to prevent the deposition taking place too suddenly. Of course this will only be necessary when very strong battery power is employed. After awhile, that is when the articles are completely coated with nickel, they may be allowed to remain in the bath to acquire the necessary thickness of coating without being disturbed beyond an occasional shifting of the suspending wires.

115. It is a good plan, when a large number of Britannia metal articles have to be coated with nickel—especially if the bath is not in a favourable condition—to give such articles a slight coating of brass, by employing either of the solutions described in the earlier part of the work. After being coated with brass, the articles must be well rinsed in clean water, and at once transferred to the nickel-bath.

116. The solution for nickeling steel or iron should not be quite so strong as that used for brass or copper.

117. Zinc is more readily precipitated by sulphide of hydrogen from the solution of its chloride, than from the solution of sulphate, though both will yield up their zinc to the sulphide if the conditions referred to in §113 are fully carried out.

118. Sulphide of hydrogen may be readily made as follows:—Take, say 1 lb. of iron filings, and intimately mix with them about 4 ounces of powdered sulphur, place this in a crucible and subject to a good heat in a coke fire. Heat not quite to redness, then allow it to cool, and the sulphide of iron formed may be bottled until required for use. To generate sulphide of hydrogen gas for the various purposes referred to in these pages, put a little of the sulphide of iron in a wide-mouthed bottle fitted with a cork in which a hole must be bored to admit a glass tube to convey the gas. This tube should be bent to the shape given in the woodcut, by holding the part to be bent over a gas-burner or spirit-lamp. When the glass becomes red-hot it will readily bend, and should be allowed to cool gradually. This tube is now to be placed in the perforated cork, the shorter end being inserted and allowed to project about half an inch beyond the cork. Now add about 4 ounces of cold water and 1 ounce of sulphuric acid to the sulphide of iron, place the cork firmly in the bottle, and *at once* put the long end of the tube in the solution to be operated upon. It is well to state that sulphide of hydrogen, besides being very offensive to the organs of smelling, is exceedingly poisonous when inhaled; it is advisable, therefore, when employing it, to use every precaution, and, if possible, to conduct any operation in which it is used in the open air. The sulphide of ammonium may be formed by passing the above gas through a dilute solution of liquid ammonia, and this must be kept in a stoppered bottle.



119. A method of nickeling small articles, such as pins, hooks and eyes, &c., by boiling, has been suggested by Dr. Kayder. He first melts together 1 part copper, and 5 parts pure tin. The alloy is granulated in the usual way, but not too fine, and then mixed with water and cream of tartar into a paste. To each two hundred parts of the granulated alloy is added one part ignited oxide of nickel, and the articles laid in the mixture. After boiling a short time, they are said to become well plated. Some fresh oxide of nickel must of course be added from time to time. Brass and copper articles can easily be plated in this manner without previous preparation; those of iron must first be copper-plated. By adding some carbonate of nickel to the above bath, or to a common white bath, and boiling, a coating richer in nickel is obtained.

120. A very good solution for electro-brassing may be thus made:—In a vessel capable of holding, say 10 gallons, put 5 gallons of water and 1½ lb. of cyanide of potassium, which must be allowed to dissolve ; next add 2 lbs. liquid ammonia, and 5 lbs. carbonate of potassa ; then half fill a large porous cell with a strong solution of cyanide of potassium, and in this solution immerse several pieces of thin sheet copper. A sheet of milled brass is now to be soldered to the positive pole of the battery, and this is to be immersed in the larger solution of cyanide, &c. The negative pole of the battery is to have a piece of thin sheet copper soldered to it, and this is to be placed in the porous cell, in close contact with the other pieces of copper, and the porous cell is to be placed erect in the larger bath. The solution of cyanide should be of the same height in each vessel. The battery is now to be allowed to continue in action until there are about 15 to 20 ounces of brass dissolved into the solution from the sheet of brass—the exact weight of which should be ascertained before and after immersion. When the full amount of brass is dissolved, the porous cell is to be removed and water added to make ten gallons of solution. With one or more Bunsen's batteries, the above solution will give very good results. Fresh cyanide and liquid ammonia will have to be added from time to time, when the solution ceases to give good results. If at any time the solution becomes tardy in its action, it is a good plan to add to it a certain quantity of concentrated solution made as above. In fact, it is well to keep in stock a supply of concentrated solution with which to strengthen the bath occcasionally, for the brass anode seldom dissolves freely enough to keep the solution at its normal strength.

121. Timepiece dials which have been plated by the chloride of silver process—that is, the old-fashioned method of plating—may be replated by the same process, if required, in the following manner:—Dissolve a small quantity of silver in nitric acid, and then dilute with water. Pour in a strong solution of common salt, which will throw down all the silver in the form of chloride. Wash the precipitate thoroughly with warm water, finally pouring off the whole of the water. Add a little of common salt, powdered, to the chloride and work up into a paste. Having well cleaned the dial—which is made of brass—the paste is to be rubbed on its surface with the flat end of a good cork. By rubbing the paste on in circles, a smooth layer of silver will be given to the dial, which will retain its colour for many years. The operation of rubbing on the chloride paste must be conducted with great care, in order to ensure perfect evenness. After the dial is well coated, it is to be rinsed in hot water and dried, when it may be gently rubbed with cotton or a soft linen rag. Then repaint.

122. The most economical way to gild gold chains, &c., which are merely required to be "coloured"—that is, to have a slight coating of fine gold of good colour upon them—is first to well scratch-brush the articles, being careful to let the beer run freely, and then give them a momentary dip in a hot solution. The battery should be in good working order, and a good surface of anode exposed. When this operation is well conducted, although the work will exhibit the colour of fine gold, there will be so small a quantity of metal deposited that its weight would scarcely turn the scale. This applies mostly, however, to articles which are made of a good quality, say 16 or 18 carat gold. When the goods are manufactured of a lower standard a superior coating should be given. Many articles made of 18-carat gold, which have been frequently "coloured"—that is, boiled in the colouring salts—become so tender from the alloys of silver and copper having been partially removed from them, that it is frequently advisable to electro-gild them, rather than run the risk of colouring them in the ordinary way. The author has frequently met with chains, &c., which would scarcely bear handling, from having been coloured a great many times. It is necessary to be very careful in scratch-brushing such tender work, as breakages become very embarrassing to the electro-gilder. Only the extreme points of the scratch-brush should be employed, and very light pressure given.

123. All kinds of wire-work, but more especially filigree-work, require to be coated in a solution containing a fair amount of gold. The battery should be vigorous, and a good surface of anode exposed. Unless these conditions are observed, wire-work is liable to receive the deposit partially. When the current is tolerably strong, if the articles are gently moved about while in solution, those parts which are most difficult to gild will more readily receive the deposit; and when once the article is coated all over the deposition will proceed with greater uniformity. It is a good plan, however, to scratch-brush the articles as soon as they have become coated, and then to immerse them in the bath until finished.

124. The insides of cream-ewers, mugs, &c., should never be gilt with an anode which is thin and much worn at its lower edge; otherwise small particles of gold will fall from the anode, and becoming deposited on the bottom of the vessel, these particles will prevent the deposit of gold taking place at the parts on which they have rested. When the anode is thin and ragged from long use, it is better to cut away the ragged portion before employing it for insides of sugar-basins, &c. A stout anode is, of course, preferable to a thin one, but with the precautions we have suggested the latter will answer very well. A cylindrical anode is better than a flat one for the insides of vessels, inasmuch as it causes the deposit to take place more uniformly—especially in the hollows of chased work.

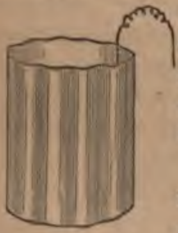
125. In cases where it is not desirable to remove the tin from the bottoms of old cruet-frames, the tinned surface may be coated with a thin layer of copper by simply applying a sponge dipped in a weak solution of sulphate of copper, to which a few drops of sulphuric acid may be added; and by touching the part to be coated with a thin strip of clean iron or zinc, the tin will become instantly coppered wherever the sulphate of copper has touched it. Thus part at a time may be coated with copper, and when the entire surface is coated, the article should be rinsed and then properly prepared for the plating-bath.

126. Sometimes a plating-bath, unless it be very deep, will give a rough deposit upon the lower surface of large articles, such as salvers, dishes, &c. The reason of this is that particles of dust, which had settled at the bottom of the plating-bath, become disturbed when an article of large size is immersed, and these particles settling upon the article cause the deposit to take place irregularly, and in a rough state. Not only this, but when the anodes have been long in use, and have become much worn at the lower edge, minute particles of silver fall to the bottom of the bath, and when the solution is disturbed by immersing an article of large surface, those particles of silver will settle upon the lower part of such articles, and the deposit will take place *over* them, causing a very rough and streaky coating, which will be very troublesome to render smooth enough for the burnisher. The streaky form of deposit from this cause always assumes a vertical direction. To remedy this defect, the best plan is to let the solution rest for twenty-four hours and then carefully draw it off by means of a syphon to within a few inches of the bottom. The remaining portion of the solution should be carefully filtered and then added to the bulk. Some careless persons have been known to rub the suspending-rods with emery cloth while they have been lying across the bath. This should never be done, as the particles of brass, emery, &c., would most certainly prove injurious in the way we have stated at some time or other—independent of the fact that the cyanide will act upon small atoms of oxidised brass, and thus impair the solution.

127. When a battery has been used for some time and it works slowly, it is better to throw away the contents of the cell, which will be strongly impregnated with sulphate of zinc, than to keep on adding fresh acid. An accumulation of sulphate of zinc not only retards the action, but it also prevents the acid from doing its duty properly. If there is a large excess of sulphate of zinc formed in the battery cell, it will even crystallize upon the positive element, and thus stop the action of the battery altogether.

128. Batteries should never be in alternate pairs when used for depositing gold or silver, as this intensity arrangement is apt to decompose the solution, besides rendering the work liable to strip. It is better to unite all the wires issuing from the copper into one group, and those proceeding from the zinc into another group. By doing this, the quantity of the current is increased without increasing the intensity (*vide* p. 107).

129. A form of battery designed by the author many years ago may prove of service to the electro-gilder, and therefore a brief description of it may not be unacceptable. A long strip of sheet copper is to be corrugated (as in the annexed engraving), to which a copper wire is attached; this is placed in a cylindrical jar; a stout zinc bar, amalgamated, and with copper wire cast into it, is placed in a porous cell. Dilute sulphuric acid is used as the exciting fluid for both metals.



By corrugating the sheet copper a much larger surface is presented than when a plain copper cylinder is used, and thus the quantity of the current is augmented.

An easy way to corrugate the sheet copper is to be provided with two round sticks, say half-an-inch in diameter and twelve inches long, and by rolling the copper half-way round one stick, which is placed *on* the copper and the other stick *under* the sheet, which is then bent half round the second stick. The first stick is then withdrawn and placed on the metal as before; and so on until the entire strip of copper is equally corrugated or fluted. Care must be taken to have the strip of copper of sufficient length to admit of its receiving the requisite number of turns to form a cylinder, and of the required width. The strip of copper must be about three times the length that would be required for a plain cylinder for the negative element.

130. M. Klein, of St. Petersburg, has succeeded in

king electrotypes of iron as a substitute for
per electrotypes, and it is said that the im-
vement has been eminently successful in its applica-
n to bank-note printing, &c. After having tried
ations of iron, but with only partial success, M. Klein
ast found one which answered his purpose thoroughly.
is bath consists of a solution of sulphate of iron,
m which the iron is precipitated by carbonate of
monia. The precipitate is then dissolved in sul-
uric acid. The solution must be evaporated to
el any free acid. Another bath consists of equal
ts of chlorate of ammonia and sulphate of iron.
th these baths must be used as concentrated as pos-
le. An iron anode is to be employed exposing
ut eight times more surface than the copper
hode which is to be coated presents. After being
rked some time, the deposit became faulty, which
s found to be due to the presence of acid in the
h. This acidity was proved to be due to the anode
supplying the solution with the proper equivalent
iron to replace that which had been deposited.
Klein then introduced a copper anode, as well as
iron anode, and the bath soon became neutral again,
l the deposition was more uniform. [The surface of
de *must* be extensive.] The colour of the deposit
s a dull grey, and somewhat rough, probably owing
the air-bubbles formed during the process. The
tal deposited was exceedingly hard, being nearly
al to hardened steel. When heated to cherry
ness it became malleable, and as easy to engrave
n as soft steel. The electrotype plates thus formed
said to be very durable—far more so than copper,
l hence their importance in bank-note printing.
e deposited iron is permanently magnetic. Doubt-

less M. Klein will improve upon his present process in course of time, but so far it appears to be a perfectly practical process—at least, in his hands—and the Russian Government have promptly turned the invention to account.

131. Electro-etching is another useful application of the art which is worthy of notice. A copper plate is prepared in the same way as for engraving; it is then to be coated with a mixture composed of asphalt, wax, pitch, and Burgundy pitch; and the back of the plate is to be varnished. The design is now to be drawn through the etching-ground with a fine point. When this is done, attach the plate to the positive pole of the battery, and immerse in a solution of sulphate of copper or dilute sulphuric acid—using a second plate of copper for the negative pole. After a few minutes' immersion, remove the prepared plate, dry it, and stop out the fine etched lines with varnish. The shadows are next to be traced through etching-ground, in the usual way, and the plate again placed in the bath for a few minutes. Each time after the etching-point is used in the various stages, the plate is to be returned to the bath for a few minutes, and the etching-lines stopped out with varnish as before. When the last touches have been given, the plate is to be immersed in the bath as before, and finally the etching-ground and varnish removed, when the plate will be ready for printing.

132. Gutta-percha and wax models for electrotyping may have their surfaces rendered conductible by the following plan:—Take equal parts of albumen (white of egg) and a saturated solution of common salt, and apply the mixture to the object to be coated by means of a soft brush. Then dry the composition thoroughly. Now make a strong solution of nitrate of silver and dip the mould into it for a few minutes or so, and again dry. Expose the mould to a strong light, until it becomes quite black. The mould is then to be dipped into a saturated solution of sulphate of iron, when a layer of metallic silver will be formed, upon which a deposit of copper may readily be obtained. The mould should be rinsed when taken from the sulphate of iron solution, and the battery wire attached to it, when it may be at once placed in the electrotyping bath.

133. The sulphate of iron combined with sulphate of ammonium has been recommended to form a solution for depositing iron upon copper surfaces, such as copper engraved plates, &c. Iron being much harder than copper, it is much desired to obtain a good reguline deposit of this metal upon engraved plates, by which their durability is considerably enhanced.

134. Becquerel recommends (in order to prevent the formation of peroxide of nickel in the nickel-bath) the continual addition of ammonia, by means of which the acid which is set free becomes neutralized. When the anodes fail to supply the solution-bath with the amount of nickel taken from it by the articles coated, acid is liberated, and an inferior deposit is the result. It is important, therefore, to keep the solution neutral *constantly* by the addition of ammonia, a moderate excess of which does no harm.

135. Mené takes a boiling neutral solution of chloride of zinc, to which he adds a solution of a salt of nickel; sheet or granulated zinc is immersed in this solution, in contact with which must be the articles to be coated. The solution must be kept neutral.

136. Stolba deposits nickel or cobalt by forming a bath consisting of a solution of either metal, to which is added a dilute solution of chloride of zinc. A piece of metallic zinc is put in contact with the articles to be coated. A little hydrochloric acid is also added.

137. According to Jacobi and others, it is not necessary (as Mr. Adams says) to have solutions of nickel free from salts of potassium and other alkaline salts, as a solution may be made with the double sulphates of nickel and potassium.

138. In working brassing solutions, Mr. Walenn says that the evolution of hydrogen at the cathode may be entirely stopped by employing *very* strong solutions of brass. When, therefore, the solutions become exhausted, fresh concentrated solutions of copper and zinc should be added to the bath. Mr. Walenn believes that the evolution of hydrogen in brassing solutions is owing to the small quantity of metal in solution, for when a larger amount of metal is employed, the evolution of this gas stops. He also prefers working these solutions hot.

139. Articles composed of iron may receive a stout and a durable coating of copper or zinc by first coating them well in an alkaline bath (see p. 35) and then giving them a final coating in a so-called acid-bath, that is, a solution of either sulphate of zinc or sulphate of copper. These solutions, however, should be carefully neutralized by carbonate of soda or ammonia before using them for this purpose.

140. Plaster busts may be reproduced in electrotype by first coating the plaster with wax and then applying plumbago in the usual way. Upon this, copper is deposited by the battery of sufficient thickness to bear handling. The plaster is then to be broken away from the electrotype (which now forms the mould), and this is to be slightly rubbed over with oil. The mould is then to be placed in the bath until a sufficiently stout impression is obtained, when the copper mould may be broken away, and the electrotype bust, after being well freed from grease, may be bronzed by any of the processes described, or polished bright if desired.

141. Electrotyping, as it is termed, consists in taking an impression of the type in wax or other material, coating as usual with plumbago or other conductor, and then depositing a thin coating of copper, which is afterwards strengthened by running in type-metal.

142. Embossed cards, or paper (envelope crests, for instance), may readily be copied in electrotype by first saturating the paper slightly with wax. Plumbago is then to be brushed over in the usual way, when a deposit of copper will readily take place, and a perfectly sharp impression obtained.

143. Leaves, flowers, &c., may be copied by first dipping them in a solution of phosphorus in bisulphide of carbon, and then into a solution of nitrate of silver. The silver becomes reduced to the metallic state, which renders the object an excellent conductor.

144. Batteries which have a copper cylinder for the negative element, may have their *quantity* augmented by placing fragments of broken electrotypes at the bottom of each battery cell in close contact with the cylinder. The author has employed old rifle-caps for this purpose, placing several hundreds in each cell, by which means the quantity of the current was increased up to a certain point in proportion to the extra surface of copper thus presented.

145. Lace, net, and other similiar fabrics may be coated with copper, by first dipping in melted wax.

The superfluous wax must be removed by placing the net between two layers of blotting paper, and then passing a heated iron over the surface. Plumbago or bronze powder is then to be applied, and the article will be ready for the coppering bath.

146. Glass vessels may be covered with copper by varnishing or coating them with wax in the first place, and then applying plumbago, after which they are ready for the coppering bath.

147. It is a good plan to give a coating of varnish (shellac dissolved in spirit of wine, for instance) to the outer edges of electrotype moulds, to prevent the deposit of copper taking place upon those parts, but the varnish must not be too thin, nor too freely used, otherwise some of it may find its way upon the surface of the mould and thus render the impression imperfect. Grease of any kind, carefully applied, will answer the same purpose.

148. Silver bronze, as a conducting medium for electrotype moulds, may be very easily prepared as follows:—To a solution of nitrate of silver add sufficient solution of common salt to throw down all the silver in the form of chloride. Wash the precipitate several times, finally pouring off nearly all the water; now put in a piece of pure sheet zinc and add a few drops of sulphuric acid. Apply moderate heat, and in a few hours the chloride will be converted into a delicate bronze of pure silver, which should be washed several times with hot water, and finally dried on filtering paper. This silver bronze should be kept in a bottle well corked, as it would lose much of its conducting power if allowed to be exposed in a vitiated atmosphere.

149. Gold paint has sometimes been used to give a conducting surface to articles of a delicate nature.

150. Sealing-wax impressions do not readily receive a coating of plumbago; it is a good plan, therefore, to apply with a soft brush a little spirit of wine to the impression before plumbagoing; but this must be done with care, as the spirit, if too freely used, will dissolve the sealing-wax, and thereby spoil the impression. The object of employing the spirit of wine is merely to impart a *very slight* roughness.

151. Hooks and eyes, and other small articles which require to be silvered or gilt in large quantities, may be conveniently placed in an earthenware colander, the perforations of which should be tolerably large in order to admit the free exit of liquids. Hooks and eyes which are made of brass should be first dipped into a solution of caustic soda or potash to remove grease, and then be well rinsed. They must then be dipped for an instant in "dipping acid," and again rinsed several times. The perforated vessel, containing the hooks, &c., should then be placed in the bath, and the negative electrode put in contact with the hooks, and by employing this electrode as a *stirrer*, while deposition is going on, the articles will become uniformly coated all over; otherwise, were they not to be moved about, those parts which were in contact would not receive the deposit. Iron hooks and eyes should be first coated with brass or copper before being plated.

152. A solution of platinum, from which this metal may be readily deposited, is formed by adding a solution of chloride of ammonium (sal-ammoniac) to a solution of chloride of platinum. This mixture should be boiled for a short time, and then set aside to cool. Before using the solution, liquid ammonia is to be added gradually, until it is neutral to test-paper. The platinum solution will require strengthening with a concentrated solution of the double salts each time after it has been used.

153. Another process for platinizing consists in taking a solution of the chloride of platinum as nearly neutral as possible, to which is to be added a strong solution of caustic potash until all the platinum is thrown down. The precipitate is to be well washed with equal parts of alcohol and water, and finally with alcohol alone. The precipitate is then to be dissolved in hot distilled or rain water, and is ready for use. The solution is to be used while hot, the articles to be coated being dipped into it. After a few moments' immersion the article will at first appear somewhat dull, but soon assume a more brilliant appearance when the operation is complete. After the necessary deposit is obtained, the articles should be rinsed in boiling water and then dried in very clean box sawdust.

154. Lead may be successfully deposited from the following solution :—Dissolve about 3 ounces of litharge in a solution of caustic potash, and made into 1 gallon of solution. A leaden anode is to be employed, and the strength of the solution may be kept up by adding fresh litharge from time to time if required. Articles well coated with lead will resist the action of many acids, alkalies, &c.

155. For depositing palladium from its solutions, the double neutral chloride of palladium and potassium have been recommended. Equal proportions of the salts should be employed, and the deposit allowed to take place after the manner of platinum.

156. Professor Jacobi introduced a very simple form of brassing solution, and one which, in the hands of an experienced operator, would give very good results. Having prepared a concentrated solution of cyanide of potassium, a copper anode is to be connected with two or three pairs of Smee's batteries, or one large Bunsen, and a sheet of zinc attached to the negative pole of the battery. These two plates are to be immersed in the cyanide solution, and galvanic action kept up until the solution has acquired the requisite amount of copper. This becomes manifest by the zinc plate eventually becoming coated with this metal. The copper anode is now to be withdrawn, and a zinc anode substituted, the action of the battery being continued until the copper coating on the sheet zinc acquires the characteristic colour of brass, when the operation is complete, and the solution ready for use. The addition of cyanide from time to time will be necessary; and, doubtless, the addition of liquid ammonia, for reasons before given, would aid in keeping the zinc salt in solution. The above solution must be worked with a brass anode and vigorous battery power; for small articles a single Bunsen's battery will be sufficient, but for larger articles two or more cells would be required.

157. It has been stated that by adding small quantities of caustic soda or potassa to a solution of sulphate of copper for electrotyping purposes, the speed of the operation is greatly enhanced. The potassa or soda should be added to the solution of sulphate until the precipitate formed ceases to become re-dissolved by the solution.

158. By employing *very* weak solutions of copper or zinc from their sulphates, and rendering them neutral by means of a small quantity of carbonate of soda or potassa, a very tolerable coating of either metal may be imparted to iron or steel; but it is always preferable, in the first instance, to give a slight coating in an alkaline bath, and then to finish in the above solutions.

159. Since the deposition of iron upon copper surfaces, such as engraved plates, and the coating of type with iron, are now things to be desired, the experimental reader will do well to turn his attention in this direction, as, doubtless, much will be required in this branch of electro-metallurgy in time to come, and the inventor's labours, if successful, it is to be hoped may meet with the reward which will be their just due.

160. Gilt articles of an inferior colour may be improved by coating them with a substance known as "gilder's wax." This article may be readily made by adding red ochre, alum, and verdigris, to beeswax in a melted state. The compound is to be applied to the gilt work by heating the article and passing the wax over it, by which means sufficient will attach itself to answer the purpose. The article is then to be placed on red-hot charcoal until all the wax is burnt off. It is then to be placed in very dilute sulphuric acid, and then scratch-brushed. All articles must be well gilt before this process is applied.

161. The proto-nitrate of mercury in solution is useful in cases where the deposited metal has a disposition to separate, or strip, from the metal coated. This salt may be made by putting a few ounces of mercury into a Florence flask, and then adding diluted nitric acid—say 1 part acid to 2 parts water and applying gentle heat; care must be taken not to have an excess of acid. When the red fumes at first formed disappear, the solution should be set aside, when the proto-nitrate will crystallize. The supernatant liquor should then be poured off, and the crystals gently dried at a moderate heat. The crystals may then be dissolved in water, and the solution applied by dipping the article for an instant, until it has become thoroughly coated with mercury. It is important to avoid contact with the solution of mercury, and to rinse the fingers at once if they have accidentally become moistened with it, and this for two reasons; first, the mercurial salt is injurious, and second, if it is allowed to come in contact with any gilt surface it will impart a coating of mercury to the part affected.

162. Since this work was first published, magneto-electricity has been much used at some of our larger electro-plating establishments for the deposition of silver, and thus the battery has, to a certain extent, become superseded. Although it is questionable whether, in an economical point of view, magneto-electricity presents any positive advantage, manufacturers find that by its agency they can secure the deposition of a larger amount of metal in a given time than could be obtained from the batteries ordinarily in use; and this is unquestionably an advantage. Where steam-power is required for other purposes, the cost of keeping a magneto-electric machine in action would not, in our opinion, be a very important expense as compared with the cost of battery power, especially when a superior amount of deposited metal is taken into consideration. One of the first of these machines was constructed for the author's establishment as far back as 1847, and, although it was far from being perfect, it gave evidence that magneto-electricity would one day give the current which electro-metallurgists would employ for their operations. The author, being desirous of giving the reader a full knowledge of what is being done in magneto-electricity, has taken much pains to endeavour to acquire such information upon this subject as would be interesting in a practical point of view; but not having fully satisfied himself, he will leave to a future day a more elaborate description of the deposition of metals by the electro-magnetic current, and he will tender his best thanks to those who will kindly furnish him with such details as will enable him to accomplish so agreeable, and at the same time so important, a task.

163. Another preparation for colouring gilt or gold articles consists in mixing together nitrate of potash 5 parts, alum 2 parts, sulphate of iron 1 part, and sulphate of zinc 1 part. The ingredients are to be well mixed, and then water added to form a paste. The article to be coloured is to be dipped in the mass, then gently shaken to remove superfluous mixture, and placed upon a sheet of iron or copper, and heated until dry; the heat is then to be increased for two or three minutes, and the article is then to be plunged into cold water, and treated as usual to finish.

164. The substance known as "crocus," and which is so exceedingly useful as a polishing medium for steel, &c., may be very generally obtained in the cinders produced from coal containing iron. It will be easily recognized by its rusty colour, and should be collected and reduced to a powder for future use. Steel burnishers may be brought to a high state of polish with this substance by rubbing them upon a buff made of soldiers' belt or hard wood. After this operation the burnisher should be rubbed on a second buff charged with jeweller's rouge.

165. French bronze may be prepared by reducing to a powder, hematite 5 parts, and plumbago 8 parts, and mixing them into a paste with spirit of wine. Apply the composition with a soft brush to the article to be bronzed, and set it aside for some hours. By polishing *with a tol*erably hard brush, the article will assume the beautiful appearance of real bronze. The desired tint may be regulated by the proportions of the ingredients.

166. A very good imitation of the antique bronze green may be made by mixing strong vinegar half a pint, chloride of ammonium (sal-ammoniac) a quarter of an ounce, liquid ammonia half an ounce, common salt a quarter of an ounce. Brush this composition over the copper surface, repeating the operation each time after it has become dry.

167. Gold, and other solutions which are worked hot, should always have fresh water added to them after they have been in use some time, otherwise they will be apt to give ununiform results. When a gold solution, for instance, has been heated, say over a lamp for an hour or so, the solution will have become considerably diminished *by evaporation*, and unless this loss be made up by adding water, the solution will be stronger than it was at starting, and consequently the results will be liable to vary. It is a good plan, therefore, to keep the depth of the solution gauged, so that when there is an appreciable diminution of the bath, the deficiency may be re-supplied. The small amount of solution removed by each article may, of course, be allowed for, but evaporation is the great source of diminution in the original quantity of the bath.

168. A very beautiful bronze colour may be imparted to copper articles, such as medals, for instance, by boiling them in a solution composed of verdigris 5 ounces, muriate of ammonia 5 ounces, strong vinegar half an ounce. Mix the verdigris and sal-ammoniac by pulverising in a mortar, and then add a sufficient quantity of the vinegar to form a paste. Now place this in a copper vessel with a pint of water, and boil for about a half an hour. When cold, stand the mixture aside until the sediment has subsided, when the clear liquor may be poured off, and bottled until required. The articles to be bronzed should be boiled in this liquor for ten minutes or longer, taking care that they do not come in contact during the operation.

169. Whenever there is evolution of gas at the negative pole during the operations of gilding or plating, it is a sure sign either that the battery power is too strong, the surface of anode in solution excessive, or there is too great an excess of cyanide in solution. Under either of these conditions the deposit will be faulty, and liable to strip. There should be no effervescence whatever at the negative electrode if the operation is proceeding satisfactorily.

170. A very pleasing effect may be produced upon an electrotype medallion thus :—Having well cleaned the electrotype by any of the processes given, apply varnish, with a soft brush, to the base or flat surface, carefully avoiding the figure ; when the varnish has become hard, attach a wire to the electrotype, and place it in the gold or silver bath for a short time until sufficiently coated. Now remove the varnish and apply the solution of chloride of platinum or other bronzing material to the copper surface, and thus the figure will stand out in relief, either in gold or silver, as the case may be. By employing the solution mentioned at page 44, the figure will appear dead white. A very slight coating of thin chloroform varnish will protect the silvered surface from oxidation.

171. When two surfaces of a medal have been copied, and it is desired to unite them so as to resemble the original, this may be readily done by cutting a *strip of* copper from a thin sheet, forming this into a ring of the size of the medal, and carefully soldering it to its edge. A good plan is to tin the inner surface of the copper ring, as before recommended under the head of soldering, and by a moderate heat the ring can be made to attach itself to the edge of the medal. A smooth file and emery cloth properly applied, will soon render the operation complete, and by this means a perfect copy of the original medal will be obtained.

172. Acetic acid, or strong vinegar, verdigris, and chloride of ammonium, in varied proportions, will give rich bronze tints to copper by boiling the article in a solution of the ingredients for a few minutes, the tint being regulated by the proportion of chloride of ammonium in the composition. Acetate of copper added to the mixture will also vary the tone. The articles, when removed from the solution, should be well rinsed in hot water.

173. It is very important, when gilding the insides of chased and embossed work, to have all the interstices perfectly clean. A little boiling solution of either caustic soda or potash will accomplish this readily, but if a brush is applied for the purpose it must be well rinsed after each operation, as the caustic alkali readily dissolves the bristles of which the brush is composed. After applying the alkaline solution, the article should be either scratch-brushed or well scoured with a hard brush, silver sand, and soap and water—the former being preferable.

174. The colour known as "ormolu" may be given to gilt articles by applying a mixture of alum, hematite, salt, and strong vinegar. The articles are dipped in this mixture, and then subjected to heat until the composition becomes blackened, when they are to be placed in cold water, and afterwards brushed with vinegar until quite free from the colouring medium.

175. Any small article may be either slightly gilt or silvered by simply immersing it in a solution of gold or silver, as the case may be, in contact with a piece of clean zinc, which promotes electrical action, and forms a temporary battery. The coating thus given, though not durable, is generally very adherent, especially if the deposition takes place slowly.

176. To obtain a good reguline deposit of either gold, silver, or copper, from alkaline solutions, it is absolutely necessary that the operation should begin by slow degrees. Excess of battery power in proportion to the size of the article to be coated will give a deposit which will not adhere to the subjacent metal. Again, though the current may be moderate, if the surface of anode in solution be excessive, deposition will take place too rapidly, and the deposit will not adhere. These facts should be borne in mind by the beginner, otherwise his results will disappoint him, and nothing is so disheartening to the student as failure. Although the practical operator knows well how to regulate these conditions, those who have had less experience are very apt to fall into the errors we have indicated if net duly cautioned.

177. Cyanide should never be added to a gold or silver bath until it has been fully proved that tardiness of action is *not* due to the battery. It has been a common error with some electro-platers to add cyanide from time to time when the deposit has taken place slowly ; whereas, in most instances, a diminution in the power of the current has been the cause of inaction. A large excess of cyanide is fatal to the proper working of the bath; therefore, before adding this substance the battery and its connections should be well examined.

178. When solution of salt is employed to excite the zinc in a battery, it will be necessary to remove the zinc occasionally and clean it well with a brush and silver sand. A little hydrochloric acid will assist the operation. Amalgamated plates or bars of zinc excited by dilute sulphric acid will not require this attention.

179. It has been proposed to employ a mixture of powdered zinc and plumbago to form a conducting medium for gutta-percha, wax, &c., in electrotyping. The powdered zinc may be made by melting zinc in a crucible or ladle, and when the metal is very hot, fragments of sheet-iron are to be thrown in and the heat kept up for a short time longer. Zinc in this state may easily be reduced to powder, when it may be intimately mixed with plumbago and used in the ordinary way.

180. The fumes of hydrochloric acid or of chloride of lime will produce a very good green bronze upon electrotypes, giving them the appearance of ancient bronze. Another very good way to produce this effect, is to envelope the object, if it be large, in an atmosphere of chlorine. This may be done by putting a small quantity of manganese in a Florence flask, and pouring upon it a little hydrochloric acid or sulphuric acid and salt. The gas which escapes may readily be conducted by a bent tube, inserted in a perforated cork, to the vessel in which the object is placed. The article should be exposed to the fumes for a short time, and then placed in the open air, the process to be repeated until the desired effect is produced.

181. Electro-soldering may be effected by causing a deposit of copper to take place upon the two surfaces to be united. Thus a ring of copper may be formed by turning up a stout piece of copper wire to the required shape and size, bringing the ends tolerably close together. Varnish or melted wax should then be applied to all parts of the ring excepting the extreme points that are to be joined. A part of the ring, however, should be left free from varnish, to which the conducting wire of the battery is to be attached. The ring is then to be placed in the coppering-bath, and in a short time the deposit will completely and effectually unite the two ends, forming a perfect ring. Silver articles may be electro-soldered in the same way by employing a neutral solution of nitrate of silver for a bath.

182. When a soft metal is deposited upon a hard metal, or the latter upon a metal softer than itself, the exterior metal should be polished and not burnished, and for this reason:—If silver is deposited upon lead, for instance, the great pressure which burnishing requires to produce the necessary polish would cause the softer metal to expand, and consequently a separation of the two metals would result. On the other hand, silver being softer than steel, if the burnisher is applied to silver-coated steel, the exterior metal will expand and separate from the subjacent metal.

183. When articles have been boiled in caustic alkali or "ley," to remove grease, they may be dipped in very dilute nitric acid to remove the oxide which has formed upon the surface; but if they are well brushed with moistened powdered pumice or Bath brick they may be very effectually cleansed without recourse to the acid *solution.*

184. When a bath has been at work some time, the uniformity of its condition becomes disturbed; it is better, therefore, to move the articles in solution occasionally by dipping them up and down several times, taking care, however, not to disturb any sediment which may lie at the bottom of the vessel. The rods to which the anodes are attached may also be gently moved occasionally with advantage.

185. When the current employed is too intense, the deposited metal will become excessively hard—so much so that it will be difficult to obtain a good polish by means of the burnishing-tools without considerable labour. In the early days of electro-plating many of the burnishers who entered the author's employ were struck with the difference between the work submitted to them and that which they had been accustomed to in other establishments. It appeared from the statements made at that time that in some electro-plating works the deposit was so exceedingly hard and "scratchy," that the women whose task it was to burnish it frequently worked in acute agony. When a good quantity is employed, of moderate intensity, the deposit is not only better in character, but it is more easily and successfully burnished.

186. When the gold bath is worked at a lower temperature than 130° F., the colour of the deposit is apt to be rather pale. The rich colour is undoubtedly obtained when the solution is rather above than below this temperature. If the solution, however, has been long in use, and has acquired a certain amount of organic matter, perhaps a little copper (from the positive electrode occasionally dipping into the solution when the anode is nearly exhausted), a fair-coloured deposit may be obtained below 130° F.

187. Whenever a gold solution begins to give indifferent results, more especially as to colour, the best and simplest remedy is to evaporate it to dryness. This operation always repays for the little trouble and time expended upon it, and the dried mass, when redissolved in boiling distilled water, with a little additional cyanide added, results in a gold bath which it will be a real pleasure to work with.

188. Articles of tin, lead, pewter, iron, or steel should receive a coating of copper in the alkaline bath before being either plated, gilt, or nickeled. This does not add much to the trouble, but it certainly favours the adhesion of the superior metal.

189. When an article is too large for the bath, and it is necessary to do it piecemeal, the greatest care will be necessary to obtain a good deposit at the junction between the first coating and the underlying metal. If the first layer or deposit has not been tolerably thick, when the second portion of the article has been immersed in the solution some time, it will be found that at the line near the surface of the solution the deposited metal has become dissolved, or as it were cut off. To prevent this, it will be necessary to move the article frequently while in solution until the union between the first and second coating becomes as perfect as possible. Even with the greatest care the deposited metal is very liable to strip at the junction of the two coatings.

190. *Metallo-chromes*, as they are termed, are beautiful colorations obtained by means of the battery upon plates of polished steel. The method of procedure is the following:—Make a saturated solution of acetate of lead (sugar of lead), and filter until perfectly clear. Next lay a plate of highly-polished steel in a shallow *vessel*, and pour the above solution upon it. The wire proceeding from the copper element of a compound battery of five or six pairs is then to be put in contact with this steel plate. If, now, the wire issuing from the zinc of the battery be held a short distance above the centre of the steel plate a very remarkable and beautiful effect will be produced, in the form of a series of coloured rings of great brilliancy. After a few moments these rings of varied colour will increase until the plate is covered. If a piece of copper, cut in the form of a star, a diamond, or any other shape, is attached to the end of the wire, the colorations will assume upon the steel plate a corresponding shape; and if a piece of card is intercepted between the wire and the steel plate, the colorations will take place beyond the point screened by the card. As it is rather difficult to hold, for any length of time, the copper wire with sufficient steadiness to obtain good results, the wire may be passed through a perforated card, and this allowed to rest across the vessel in which the operation is performed. The colours produced by this beautiful process resemble those obtained by the prism, but as they do not adhere closely to the metal plate, the latter should be carefully washed in boiling distilled water, and when dry the plate may be varnished with any good white spirit varnish. The coloration of metals by electricity was first discovered by Dr. Priestley, but it was Nobili who first obtained coloured deposits upon metallic surfaces as described above.

191. Woodcuts may be coated with plumbago and then copied in electrotype. The reverse thus obtained may in its turn be slightly oiled, and then placed in the bath to receive a deposit which will be as sharp as the original, and the same copper mould may be employed again and again for the same purpose.

192. Intaglios, or moulds, may be obtained from medals, coins, &c., by pressing them upon tin-foil, which will readily receive the required deposit of copper. To give additional strength to the foil, melted wax, sealing wax, or stearine may be employed.

193. Sheet or bar iron may be employed in place of zinc as a positive element for a constant battery, but the acid solution employed to excite it should be weak.

194. For the convenience of jewellers, watchmakers, and amateurs living at a distance from large towns, the author has designed an electro-metallurgical cabinet containing everything that will be necessary to enable its possessor to carry on the operations of electro-plating and gilding practically; and as the arrangement of the cabinet has been made with considerable care, so that it should be serviceable not only as a means of studying these beautiful arts, but also as a source of profit to those who desire to use it for such purposes, it is to be hoped that it will meet the wishes of those for whom it was projected. The manufacture of this cabinet has been entrusted to Messrs. How & Co., of St. Bride Street, London, the successors to the late eminent firm of George Knight & Sons.

195. Nickel may be deposited upon copper for experimental purposes from a solution of its chloride, by placing a piece of clean zinc in contact with the copper while in solution. The solution should be warm. Cobalt, iron, and other metals may also be deposited in a similiar way, the strip of zinc performing the office of a battery.

196. The "single cell" arrangement will be found very useful for obtaining deposits of the various metals from their respective solutions, when the object of the *manipulator* is merely to give a slight coating as an illustrative experiment; and in this case a very small porous cell, supplied with a small bar of zinc with copper wire attached, will be quite sufficient to coat small articles with any given metal. When the same apparatus is employed to deposit several different metals from their solutions, the porous cell, &c., should be thoroughly well cleaned after each solution has been used. The student may obtain a very interesting collection of electro-deposited metals by coating small pieces of sheet copper with the various metals, and arranging them in a cabinet, duly labelled. The strip of zinc suggested in the foregoing paragraph, and a very small quantity of solution, will be all that is required to coat a small piece of copper with almost any metal. A series of small coins, copied in electrotype, and then each coated with a different metal, would form a very interesting collection.

197. In commencing the study or practice of electrodeposition, after reading this work, the first question that will occur to the student is, "What apparatus and chemicals shall I require?" Therefore, well knowing how useful such information in a brief form will be, we have thought it advisable to give the subjoined list of things which are either indispensable or may become necessary, either to the student who works for pleasure, or to those who work for profit.

198. LIST OF ARTICLES REQUIRED IN ELECTRO-GILDING, PLATING, ETC.

Gilding battery-jar.
Plating battery-jar.
Gilding bath, of glass or stone-ware.
Plating bath, of wood or stone-ware.
Gold anode rolled out to a moderate thickness.
Silver anode rolled out to a moderate thickness.
1 lb. of stout copper wire.
1 lb. of thin copper wire for slinging.
One or two Bath bricks, to be rubbed together until powdered, or
A few pounds of powdered pumice-stone.
Several brushes, consisting of 1, 2, 3, and 4 rows each.
Several sheets of emery-cloth, Nos. 1, 2, and 3.
Several lumps of pumice-stone.
A Water-of-Ayr stone about three-quarters of an inch square.
Pair of flat pliers.
Several files.
Chamois leather.
1 ounce of rouge.
½ lb. of mercury.
Several binding-screws.
A few sheets of filtering-paper
1 quart of box-sawdust.
Several scratch-brushes, which, for economy sake, may be cut in half, and the ends soldered.
Scratch-brush lathe and "chuck."
Evaporating dish to hold half a pint.
Rotten stone, 1 lb.
Borax, 1 ounce.
Silver solder.
Soft solder.
Blowpipe.
Rosin.
Soldering iron.
Cyanide of potassium for silver bath.
Cyanide of potassium for gilding bath.
Nitric acid.
Hydrochloric acid.

Sulphuric acid.
Sulphate of copper for electrotyping.
Burnishers.
Nitrate of mercury (made by dissolving mercury in nitric acid).
One or two "buffs" for polishing.
Charcoal, several pieces.
One or two glass measures.
Nitrate of potash for stripping solution.
Fuming nitric acid.
Acetic acid.
Sal ammoniac.
Scales and weights—small and large.
Sheet copper for gilding battery.
Sheet copper for plating battery.
Stout sheet zinc for plating battery.
Stout sheet zinc or cast-zinc bar for gilding.
Ox gullet or porous cell.
Carbonate of potassa,
Fine silver for solutions.
Fine gold for solutions.
A few gallons of distilled or rain water.
Bisulphide of carbon for "bright" plating.
Common salt.
Caustic soda (see p. 48).
Silver sand.
Jar for stripping solution (see p. 56).
Plumbago, and a camel's-hair pencil.
A tub, or other vessel for cleaning work.
Several pans or rinsing vessels.
Brass rods to suspend articles to be plated.

FRENCH MEASURES OF WEIGHT.

		English grains.
Milligramme	=	·0154.
Centigramme	=	·1543.
Decigramme	=	1·5434.
Gramme	=	15·4340.

MEASURES OF VOLUME.

1 litre = about 34 English fluid ounces.

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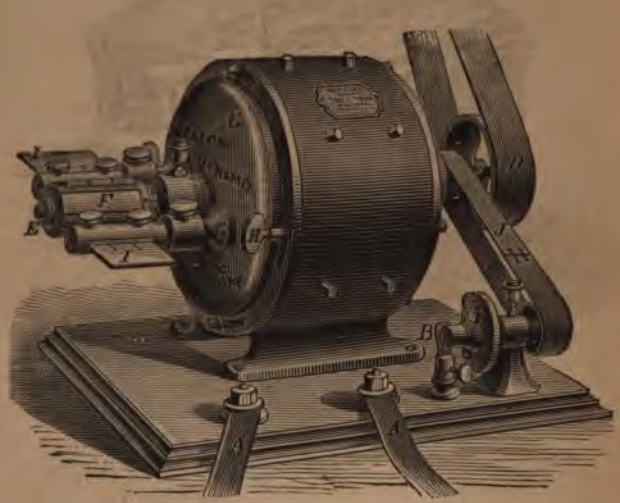

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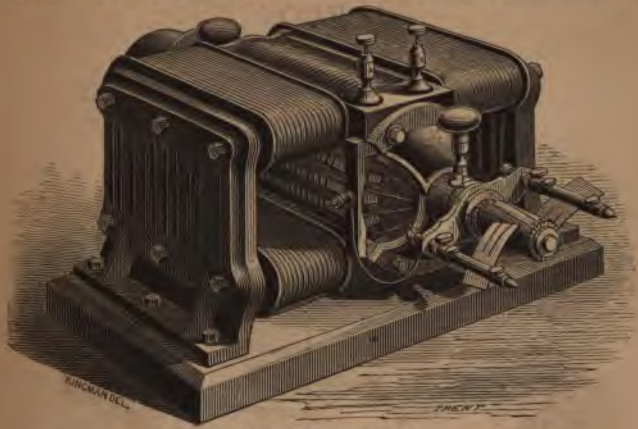

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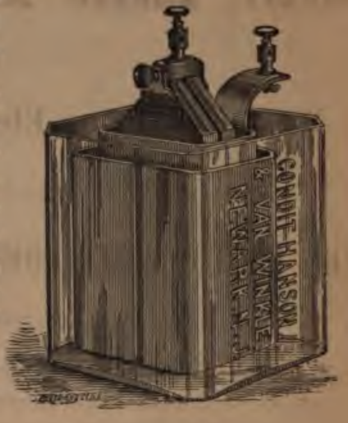

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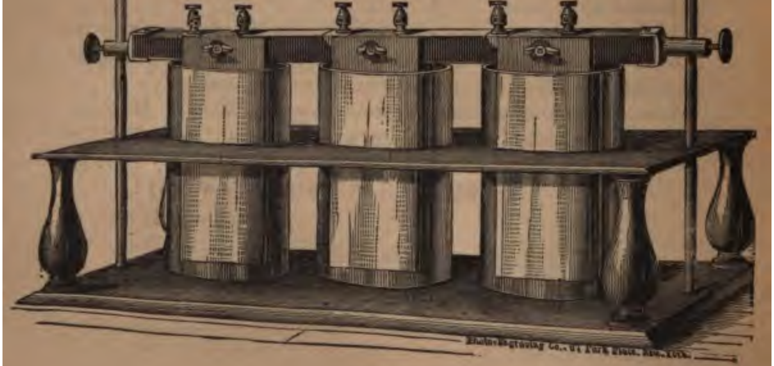

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